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**STEEL PASSENGER EQUIPMENT.\***

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**THE UNDERFRAME.****Synopsis.**

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**Historical.**

That branch of transportation engineering which is exemplified by the most approved wooden railroad equipment and to a greater degree by the contemporaneous developments in steel or metals is a comparatively new and eminently thorough science.

Adaptability is one of the prominent characteristics of America and no matter to what degree the comforts and luxuries of travel be increased, just as surely do the people make use of them as their own and seemingly forget the yester-year. The efforts put forth for the betterment of transportation conditions have produced a stage of development which makes it difficult to conceive of equipment (within the life time of a man) which was so very primitive and from which our modern palaces of travel emanated.

Eighty years ago there were no railroads engaged in general operation in the world. The first railway passenger coach was run upon the Stockton and Darlington in 1825. There is naught about it which is particularly noteworthy, as it simply consisted of an old stage coach body which, having been removed from its running gear, was placed upon a timbered framework without even the customary leather carriage suspension. To this underframe pedestals were attached and the wheels and axles were taken from one of the company's coal cars. The whole underframe extended at both ends for a considerable distance with the evident intention of acting as a shield when the cars should come together in starting and stopping. It is interesting to note, in this connection, that the English carbuilders still separate the body and the underframe.

Five years later a little clap-boarded cabin appeared on the same road and was much less elegant than its predecessor. In this car only the side sills were extended for buffing and an entrance was placed between them at the rear.

The Baltimore and Ohio Railroad Company, in 1830, introduced practically the same car but made noticeable improvements in the seating arrangement and shortened the extension of the side sills to about half of that on the Stockton and Darlington. This car was likewise single ended and primarily intended for horse power.

The use of platforms and double entrances is shown in the Old Portage cars of 1835. The pedestals are still fastened directly to the underframe but springs have made their appearance. An iron railing guards the platform but is open in the center to permit of passage from car to car. The end sill was the strongest notice-

able up to this time and all pulling was done from the center of it.

To Harlan and Hollingsworth, we believe, should be given the greatest amount of credit for having opened up the art of passenger car building, separate and distinct from freight car, house and carriage, or road vehicle construction. Their cars, the "Columbian" of 1836 and the "Tioga" of 1840, show an advanced effort to meet the growing conditions and provide additional comforts. The former of these cars was 32 feet long and 8 feet 6 inches wide. It was more commodious than the usual type then running, having seating capacity for 48 persons with a total dead weight of 18,000 pounds. The ratio of seating capacity to dead weight was thus 1 to 375. The latter car was 4 feet longer and was without doubt the most improved car in service up to that time. The Jeffersonville, Madison and Indianapolis Railroad Company were, at this period, running equipment much similar to our work trains as far as appearances go. In these cars is noticed the use of buffers or buffing blocks on either side of the snap coupler which was fastened directly to the platform sills in much the same manner as the Camden and Amboy coaches of two years later used link couplers. The sides of these (C. & A.) cars were paneled beneath each square window. The windows were of a single sash though directly above them, set in under the eaves, was a line of narrow sashes much like the modern upper deck lights.

Up to the year 1850 there were few cars built with any center sill construction between the bolsters. Usually dependence was placed on the floor and end sills to transfer all shocks to the sides of the car. Thus the underframe consisted principally of two strong side sills and a series of cross beams to carry all strains to them. Fig. 1, taken from an old C. and A. car of this period, which is still in existence, is a good illustration of this character of framing.

Though of comparatively recent development, a study of the evolution of car framing is complicated by a scarcity of available detail material. What is at hand is not sufficient to enable the credit for having produced the trend which settled the course of our present tendencies in design, being placed upon any designer or corps of designers with any large degree of assurance as to its justice. In 1862 the Pennsylvania Railroad authorized a design since known as the Pa, but then as "The New Standard Passenger Coach." This car was a most remarkable development for the day in which it appeared and the technical journals were lusty in its praise. Fig. 2 illustrates all the distinctive features of its underframe and comparison with Fig. 1 will show the change in ideas during the intervening twelve years.

Those cars which are now considered the most improved bear a striking resemblance in the character of underframing to this early type. The ideas thus brought forward were quickly adapted and it is safe to say that the real engineering associated with the framing and bracing of passenger equipment was accomplished before 1870 and the past 40 years have but seen the detail application of these ideas altered to suit the various demands of service. Figures 3, 4, 5 and 6 are but representative illustrations of ideas prevailing at various periods during the development of the modern standards. They are self explanatory and tell their own story of progression, largely in the line of provisions for load carrying and also to a smaller extent for service shock resistance. During this period the problems dealing with architecture, ventilation, heating, lighting, braking and coupling were given precedence.

**Limitations Effecting Design.**

The economic and social needs of the country which are ever increasing have become so insistent in the past few years that the alteration of this detail application of the early ideas can not be made radical enough to meet the requirements. Thus a reconstruction of the methods now in vogue, and which ought to be followed in the future, become necessary. To secure a satisfactory basis upon which to formulate the new theories, the problem should be made a general case of knowing what are the demands of the service for which the vehicle is intended and then securing a just appreciation of the resistances and destructive forces which

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must be overcome for it to satisfactorily perform its desired function. This problem is complicated by sharp limitations such as: Lightness, Economy, Reliability, etc.

*Lightness.*—From a weight of 375 pounds per passenger in 1836 the dead load has increased to an excessive degree which

tially based upon two items, namely; the material and productive labor. For initial orders the cost, including profits, will be about 1.125 of the former and 1.875 of the latter. It is hardly possible at this stage of the art to determine the exact value of the ratio between the productive labor and the materials. This factor is so

seriously affected by the character of the design making the labor portion higher or lower as the case may be. When the industry becomes more firmly established and the designs become more standardized the whole cost may be computed as a function of the weight of the material. The figures as given above will be lower on future orders of the same class due to the improvement of shop methods for rapid production, familiarity with the equipment and the cost of new dies, templates, and jigs being eliminated.

*Economy.*—This includes initial cost, cost of maintenance and repair, and cost of transportation. The first of these costs has been partially considered. The second needs a special article to do it justice, wherein should be included all factors covering the design and construction upon which the maintenance and repair bills are dependent. The longevity of steel equipment, for data concerning which we must go to Europe, presents these problems of minimum maintenance and repair costs for solution with more emphasis than they have come to our immediate predecessors. Trautwine estimates the life of the average passenger car at 16 years (18th ed., p. 865); this is somewhat low and especially so for the most modern equipment; but at its best the

wooden construction can not compare with the results Mr. James Holden, Locomotive Superintendent of the Great Eastern Railway (England), noted as far back as 1898 concerning this point. According to a published interview he stated that he had used steel framed cars for thirty years and that cars built in 1873 still had years of service ahead of them. Thus, if maintenance, repair

reaches a maximum of 6,300 pounds in some of the modern buffet club smokers. The weights of the present wooden equipment are high. The practices of the Pullman Company, whose earliest cars were much heavier than any other class of equipment for passenger service, has no doubt had a tendency toward increasing the weights for all classes of service to secure a closer approximation toward uniform train strength. These weights should not be exceeded in the steel equipment by any appreciable amount, rather they should be reduced if this can be done in a manner consistent with proper reliability.

The question of weight directly affects the initial cost to a great degree. The tendency is now, more and more, toward basing the productive market price upon a sliding scale of costs plus a definite percentage of the costs as profits. This runs usually from 10 to 12 per cent., though keen competition and lack of orders work to make it lower. Included in the sliding scale of costs are the materials, direct or productive labor, the operative, and the administrative expenses. The second item, direct or productive labor, is governed by the amount of material and its disposition; the operating expenses are a function of the productive labor and will reach an amount somewhat over half as much. The administrative expenses are a function of all three factors, but to a much smaller degree than would be expected when it is considered that the larger salaries come usually under this head. In a well managed establishment this item should not exceed one twentieth of the combined material, productive labor and operating expenses. Thus the sliding scale of costs is essen-

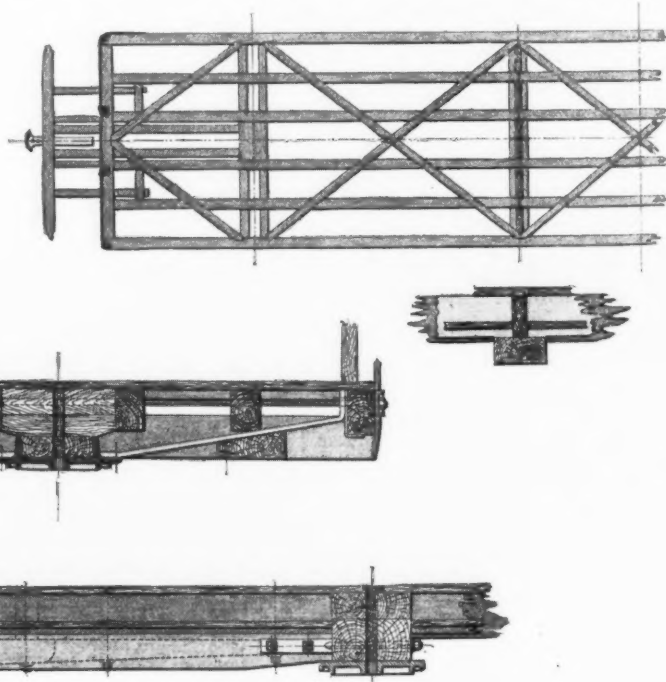


FIG. 2.

and depreciation costs are kept to a low figure, the long life of these cars will make them wonderfully economical even with a slightly increased initial cost.

The last, transportation costs, is not as definite a subject, as it deals with the proper design of trucks and side bearings to give

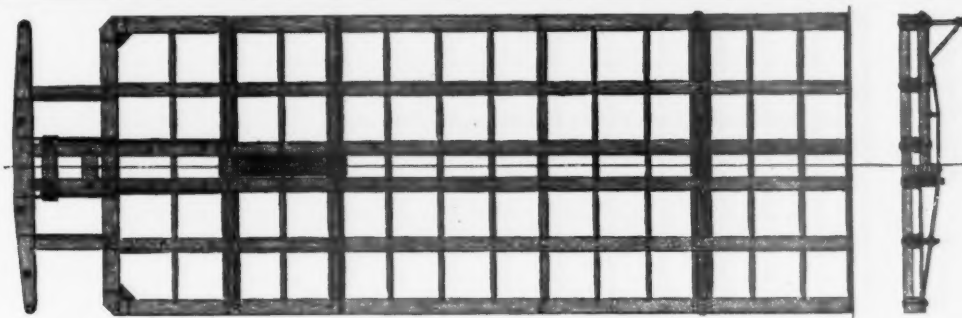


FIG. 5.

least haulage resistance, the proper design of couplers and coupler clearances so as not to bind and increase the flange friction in curving and in general the rideability of the car which directly influences travel and thus inversely reduces the revenues of transportation. The question of the real force of the value of excessive weight as affecting the cost of haulage is one upon which it is difficult to secure any adequate data. It would appear though that, since the cost of the crew and all other operating expenses, with the exception of the fuel and lubricants, are independent of the weight, a few thousand pounds more or less per car would not have much affect upon the costs of moving it when the sum total load is within the limits of the capabilities of the prime mover. This seems to be true so long as we neglect the factor of speed. Rapid acceleration and retardation, however, demand the lowest weight consistent with comfort and safety.

**Reliability.**—Safety and strength with economy, are the ends sought after by the introduction of metal bolsters, metal



FIG. 3.

platforms, full vestibules, rod and plate trusses, metal underframes, increased buffing strengths and fireproofing precautions. These qualities must be furthered in any progressive steel design.

**General.**—Aside from the foregoing limitations surrounding any intended design, principles of comfort, convenience, sanitation and car esthetics have also to be conserved. Not to do so would be a retrogression which would tend to lessen the burden of travel. These latter qualities or principles do not have as direct a bearing upon the character of the framing as the necessary requirements of reliability and the economics of production and operation, but the real merit of any design and the extreme care manifested in its completion will be shown by the disposition of the framing so as to secure a maximum of these desirable ends with a minimum of material and productive labor, and the utilization of each detail of the design to perform a multiplicity

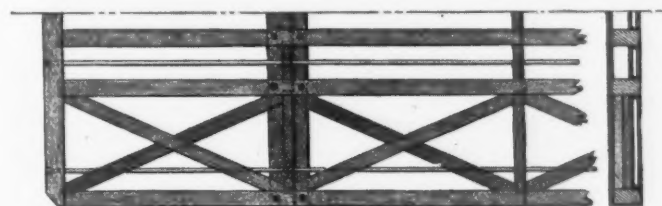


FIG. 4.

of functions wherever possible, with each proportioned to its required service. The time element involved in the designing of such equipment, by the variation of conditions in the arrangement and framing in order to note to just what degree the product can be simplified, is well repaid in the final result. The centralization of functions in one unit to eliminate numerous separate parts should, however, be solved with a regard for the facility for repairs. Other conditions being equal, the simplest design is the best and displays the best thought.

**Summary.**—The car shortage is now being felt in passenger service as well as freight and the necessity for large orders in

the immediate future, especially those for tunnel operation, warrants the building of equipment of the highest class. Since 1902 American designers have been developing those ideas in steel equipment which, though not new nor brought before the public now for the first time, are still of the highest value and worth. That they have not been used years ago is simply a question of the motive power balance sheet. Now, employing engineering practices of the best type and taking full advantage of the cost of raw constructive materials, the problem is ripe. It is hardly possible to place too much emphasis upon the fact that with the utilization of a more efficient material the new theories should bear no evidence of an unwarranted prejudice in favor of the wooden design else the best possible results be not forthcoming. Thus the problem should involve both theoretical and practical elements and steer an intermediate course, the one depending upon the other. The problem of mathematics should be exactly criticized in the light of past experience, but on the other hand practice should not be followed contrary to the fundamental laws of mechanics, a state of affairs which can readily be noticed in some few designs now before the railway world.

The more extended the experience possessed with equipment, the more evident does it become that the unexpected usually happens. There are few cases in which the cars have taken a collision alike even though in the same train and built from the same design. With the present type of wooden framing it is an impossibility to trace the mode of transference of the strains throughout the car and arrive at a just approximation of the stresses in the various members. This would indicate that an underframe should be designed, so as to take up the shocks and service strains imposed on it, from data derived by experiments and calculations, thereby securing a form that can be better proportioned to suit the requirements. This is a possibility and in the following, after these shocks and strains imposed by service have been determined, it will be shown both graphically and analytically how this can be done with a minimum weight.

#### The Service Demands as Affecting the Character of the Underframe.

Motive power designers long engaged upon the problems associated with the designing and building of cars for steam service have, during the past few years, been called upon to take into

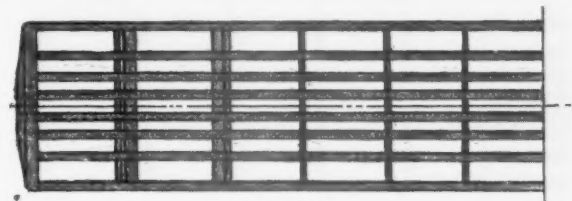


FIG. 6.

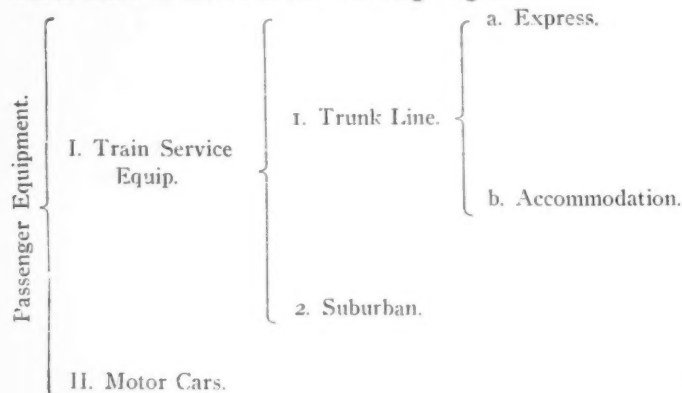
consideration the vast strides that electricity has been making for recognition as a successful competitor with steam for motive power upon its own ground. This advent, which is quite general for certain classes of service, has opened up two new types of train propulsion which must be adequately taken care of in present equipment. The problem for electric locomotive propulsion approaches closely to that for steam, while the multiple unit train control demands quite different treatment. Thus, also, what is a necessity in long distance heavy express service, no matter the choice of motive power, must be radically modified

to suitably meet the requirements for suburban and metropolitan service where choice of motive power is generally restricted by franchise to electricity. After careful consideration of these probable changes the designer with real ability displays it to the greatest degree by the means and possibilities he has taken to provide for the problems which we can now recognize as coming in the near future. The one great problem is the probable electrification of the very roads for which steam equipment is now under construction. This leads at once to the conclusion that for all such lines this equipment should be so designed that it will be susceptible of expeditious and economical modification for either type of electric control.

The multiple unit electrical control demands the most if not all the consideration. The character of the motive power unit or its probable change is thus one of the first considerations of the designer and will be dealt with in detail for each main class of service.

#### Service Classification of Equipment.

In general all car equipment can, for purposes of study, be grouped under two general types, the one should include all cars destined to be run in trains and the other all equipment run as separate motor units. This classification can then be extended much as shown in the following diagram:



For each of these classes, express, accommodation, suburban and motor, should be included all cars which are equipped to run regularly in passenger trains. These cars may not all carry passengers, but they have all their leading features in common and should present a uniform appearance and possess a uniform strength with all the other equipment of its class. Thus the express service would include coaches, baggage, postal, express, combination, parlor, sleeping, dining and miscellaneous cars. The last would include cars specially arranged inside and any other equipment which may happen to be run in the same train.

The accommodation train is seldom made up of any equipment other than the coaches, combination, and baggage cars.

The motor car service would cover the range of motive powers used for separate car running, such as gasoline, steam and electric.

#### Trunk Line Operation.

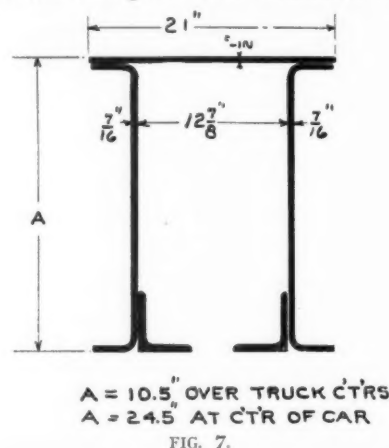
**Express Service.**—From present indications it is safe to assume that through express trains will continue to be operated by steam for fifteen to twenty years to come or until such time as the electrical engineers can so perfect their systems of transportation and control and the detail apparatus that the economies effected by changing from the existing methods would not only equal the present revenue but be sufficient beyond this to pay the charges for interest and depreciation on the cost of the new installation. The loss due to scrapping the steam equipment would be startling. Even were it admitted that the cost of transportation was smaller for electric than steam, this saving would be more than offset by the increase in the dividends upon the extra capitalization. In order that the change should pay it then becomes imperative that the long distance patronage of the road be very much augmented by the innovation. This is a matter of conjecture and leaders in the passenger traffic departments affirm it can not be done. The possibility of greatly improving the steam locomotive tends to put the day of probable change still further distant, and when it does come all signs indicate

that it will be in the form of electric locomotives. Hence for trunk line equipment operating under normal conditions the question of multiple unit control need not be considered as a factor which would affect the character of the design of the underframe. This means that, for this class of car equipment, with a floor limit of 52 to 53 inches above the rail a central backbone 18 in. to 20 in. deep can be secured over the truck center plate and a depth between the trucks limited only by track clearance.

#### STRENGTH AND RELIABILITY FACTORS.

The requirements for strength of car equipment is a subject which has been singularly neglected by the engineering societies and publications.

Though various ideas have been expressed, various tests been made and figures given for the value of end shocks, there is nothing uniformly definite about them. Nearly every builder or designer displays some pet theory in his productions which stamp them with his individuality. This is more clearly evidenced in the detail workings but very often can be traced in the general framing. An inspection of the table of center sill sections (Table No. 1) will show that there is a great diversity of opinion as to what is required to sustain the severe end shocks and provide for load carrying. This lack of uniformity in the underframing is a bad feature on account of the great difference in resisting qualities of similar service vehicles. The lighter and weaker sections will no doubt sustain the stresses imposed by load carrying, but rough handling and collisions will reveal their weakness. In considering the table mentioned it is necessary



that the radius of gyration and modulus of resistance should govern as noted farther on in the discussion. It is proper, also, to compare only those underframes which are intended for the same service.

Some authorities in car equipment have expressed the idea, that the specifications which govern the design and construction of cars should have a clause incorporated in them which would require a definite sectional area for the center sills. There are so many factors which tend to increase or decrease the stresses in these sills that such a method is hardly feasible. To make it practical would require a ruinous number of amendments providing for the variation in live and dead load transference and the eccentricity of draft and buffer attachment.

It is possible, nevertheless, to specify a minimum area for certain classes of service based upon the hazard of such operation. From an examination of the latest types of freight cars with a central buffing column, we note that the sectional area of this column over the truck centers is 38 square inches and 49½ square inches in the center of the car (the sills being fish bellied). This area is disposed as shown in Fig. 7. For all classes of service in which there is a possibility of collision with freight trains of such cars, this area (38 square inches) then should be specified as a minimum allowable section. Any increase above this would make the passenger cars just so much stronger than any rolling equipment on the road. We are not aware, however, of this idea ever having been carried out in ordering such equipment.

Other designers in drafting their specifications and cars have seemingly ignored the question of providing for these shocks directly. Starting with the idea that in a span of such length the

deflection was the governing criterion, the problem has first been solved as one of stiffness and then investigated for strength. Both of these calculations included the static loads only, and finding that the fiber stresses from these loads were less than the elastic limit of the structural materials used, the structure was deemed amply able to take care of the end shocks. To make sure of these shocks being transferred over all the longitudinal sills heavy plates and end castings have been worked into the detail underframing.

The conditions necessary to make the side sills or girders carry the end shock (which are noted in the underframe discussion)

It is possible to equate the two values of  $P$  and secure a relation between  $S$  and  $d$  which can be used in the column formulae to solve the center sills. To consider the center sills as a beam loaded both uniformly and with concentrated forces as well as an eccentric end load is probably the most exact method. To properly solve this problem it is necessary that the number, value and disposition of the various loads be known and the equation for the elastic curve expressing those conditions found and integrated twice to find the value of the deflection. Then equate this to the value of the deflection formulae which we have previously made to express a relation between strength and stiff-

NO	ROAD	SERVICE		CLASS	FORM	AREA OF SECTION	MOM. OF INERTIA	SEC. MOD.	RAD. GYR.	SEAT CAPY	WT. OF CAR BODY LBS.	WT. PER PASSENGER LBS.	REFERENCE A.E. & R.R. JOUR.
		ST	CL			A	I	$\frac{I}{c}$	$r = \sqrt{\frac{I}{A}}$				
						SQ. IN.	IN <sup>4</sup>	IN <sup>3</sup>	IN				
1	ILL. CENTRAL	"	"	PASS.	3	12.62	169.8	37.8	3.67	100	61,400	614	6-03, 5-03, 10-03
2	INTR. RAPID TRNS	"	"	"	3	7.2	27.2	10.8	1.94	52	27,000	519	3-03, 10-04
2 <sub>1</sub>	" " "	"	"	"		25.5	870.2	34.8	1.84				" "
2 <sub>2</sub>	N.Y. SUBWAY	"	"	"	1	10.14	52.4	17.4	2.27	52	34,000		" "
3	70 FT. (G.I. KING)	"	"	"	3	38.7	1264.68	182.49	5.71				
4	SOUTHERN	"	"	"	3	34.875	1702.02	133.91	6.97				7-06.
5	LONG ISLAND	"	"	"	1	10.14	52.4	17.4	2.27	52	38,278	734	9-06
6	SANTA FE	"	"	POSTAL	3	31.	2830.8	220.64	9.55				10-06
7	SOUTH. PACIFIC	"	"	PASS.	3	18.52	431.6	72.	4.83	70	75,550	1079	1-07
8	LONG ISLAND	"	"	"	1	17.64	268.4	53.6	3.30	72	72,500	1007	2-07
9	N.Y.C. & H.R.R.R.	"	"	"	1	10.66	113.8	28.4	3.27	64	67,170	1,049	3-07
10	P.R.R. (1651)	"	"	"	2	55.86	3645.14	383.69	8.07	72	78,450	1,089	6-07
11	P.R.R. (6546)	"	"	POSTAL	2	"	"	"	"		89,500		4-07, 6-07
12	P.R.R. (70 FT)	"	"	PASS.	2	50.	3202.98	337.15	8.	88	88,400	1,004	6-07, 7-07
13	P.R.R. (60 FT)	"	"	BAGGAGE	2	"	"	"	"		67,900		7-07
14	P.R.R. (70 FT)	"	"	DINING	2	"	"	"	"	30	101,000	3,366	7-07
15	SOUTH. PACIFIC	"	"	POSTAL	3	18.52	431.6	72.	4.83				6-07, 7-07
16	UNION PACIFIC	"	"	"	3	"	"	"	"				6-07, 7-07
17	ERIE	"	"	"		36.03	2927.92	259.79	9.01				
18	N.Y., N.H. & H.R.R.	"	"	"		"	"	"	"				
19	PULLMAN	"	"	SLEEPING		34.77	783.63	98.56	4.74	30	125,000	4,166	4-07
20	P.R.R. (P53)	"	"	PASS.	2	32.24	2038.17	214.54	7.7	64	64,900	1,004	
21	C.I. & L.R.R.	"	"	COMBINED	3	10.66	113.8	28.4	3.27	16			
22	LONG ISLAND	"	"	PASS.	2	24.32	433.27	82.53	3.7	72	50,000	694	7-07

For reference to No. 3 see *M. C. B. Proc.*, Vol. 38, and to No. 21 see *R. R. Gazette*, 1903, p. 452. † Estimated.

TABLE NO. 1.

have not otherwise been fulfilled in any design thus far given publicity and calculated as indicated above.

The laws for stiffness of beams are much different than those for strength. The stiffness of a beam is measured by the load it can carry with a given deflection. The strength of a beam is measured by the load it can carry with a given fiber stress. The stiffness varies directly as the coefficient of elasticity, the moment of inertia, and inversely as the cube of the length, while the strength varies directly as the moment of inertia and inversely as the length. Putting these in the shape of formulae:

$$\text{For stiffness} \\ P = \frac{EI d}{L^3} \times K_1.$$

$$\text{For strength} \\ P = \frac{SI}{Lc} \times K_2.$$

Where  $E$  = coefficient of elasticity;  
 $I$  = moment of inertia;  
 $d$  = deflection;  
 $L$  = length in inches;  
 $S$  = working stress;  
 $c$  = distance from neutral axis to most extreme fiber and  $K_1$  and  $K_2$  are constants depending upon the character of the loading.

ness. This can be accomplished with great ease graphically and the graphic curve indicates a very close approximation which is shown later on.

**End Shock.**—It will be noted that an assumed end shock is necessary in the above method. The assumption of this is the nucleus of the method we believe should be used to cover this question in the specifications.

From dynamometer tests made upon the Lake Shore and Michigan Southern Railway (1902), it is shown that with careful handling the pulling strains will reach 50,000 pounds, and 100,000 pounds with rough service. For buffing the former strains will be at least doubled, and tripled for the latter. This figure of 300,000 pounds is considered low by the prominent steel car companies and railroad officials independently designing their own equipment. These men are now introducing buffers and draft gears with a combined capacity of over that amount. From an investigation of the repair yards for steel cars following the discussion of this subject in the Pittsburg Railway Club (1905) we believe the best requirement for trunk line cars to be,—those portions of the underframe which are designed to resist end

shocks must be fashioned to withstand a static tensile load of 150,000 pounds for pulling and a static compressive load of 500,000 pounds for buffing and that the stresses occasioned by these loads when combined with the stresses due to dead and live lading shall not total more than the elastic limit of the material. This limit should also be given in the specifications.

This value of 500,000 is high for even severe service handling and especially so for the passenger service, but the stress is likewise allowed to reach a good figure.

The net area of tension flanges or beams should be taken when considering the stresses for a final investigation of the center sills and for the compressive flanges or beams this allowable stress should be modified so as to introduce the relation between the length of the column ( $L$ ) and the radius of gyration ( $r$ ) of the column section. The formula of the American Railway Engineering and Maintenance of Way Association shows that the stress should be reduced by  $70 \frac{L}{r}$ . Hence for allowable compressive unit strains at the shock considered, it should not be greater than, elastic limit— $70 \frac{L}{r}$

The net area in the compression flanges need not be considered if the inspection is rigid enough to secure first-class workmanship as in that case the rivets may be assumed to completely fill the holes.

It is a difficult matter to locate any line of demarcation between severe service and operating collisions. The above specification clause would take care of most of the road accidents and beyond that afford additional, though weakening, strength up to the ultimate. The deflection of these sills must be taken care of and prevented in the best manner possible, for when a compression column fails, as these would, by lateral deflection the elastic limit strength and the stiffness are the determining elements of the collapse rather than the ultimate strength.

The arching of the center sills in riveting them up is a good feature in this connection. They should have sufficient upward camber so that when the weight of superstructure is placed upon them, the neutral axis will be forced down to a perfectly horizontal line. The method of fastening the intermediate cantilevers to the longitudinal sills should be such that if an excessive shock tends to produce a dangerous deflection, the center sills can call upon the side sills to work closer to their elastic limit and help sustain a part of the flexural load caused by such deflection. The use of truss rods are not of much avail because with an underhung draft gear this excessive load would put the rods in compression.

In a number of earlier designs during the transition period flitched (composite) girders of wood and steel were used for this purpose, the idea being that the iron should reinforce the wooden beams. This, however, did not work successfully since, due to the difference in the moduli of elasticity, the steel took all the load. The cars were not designed with this intention and they failed in service. Cars were later designed, after such failure, and the wood simply used for fastening purposes, then the area of wood was gradually reduced to the point of elimination. This accounts for some steel cars which are an accurate counterpart of the old wooden framing.

Mr. G. R. Henderson gives as a requirement in his specifications for freight cars, "..... the center sills and draft attachments must be proportioned for a force of 100,000 pounds pulling, and 200,000 pounds buffing, and strains due to either or both the horizontal forces and the vertical loading combined must not exceed 12,000 pounds per square inch in tension and  $12,000 - 70 \frac{L}{r}$  in compression, where  $L$  = length and  $r$  = radius of gyration, both in inches." If it be assumed that Mr. Henderson's and the author's specifications be applied to the same car it would mean that for the same stress to be acting, the elastic limit would be 30,000 pounds per sq. in. This a good average figure for structural steel, a number of the prominent engineering firms as well as city building laws placing the limit from 3,000 to 5,000 pounds higher and a few railroads 2,000 lower.

If further investigation and tests reveal the assumed relation

between the end shock of 500,000 pounds and the elastic limit of 30,000 pounds per square inch to require too high an efficiency from the underframe we would favor raising the 500,000 to the necessary value for a safety factor and preserving the specified elastic limit.

The statement that the stresses should not exceed a specified limit of, say, 12,000 or 15,000 pounds per square inch does not in reality secure the uniformity in strength that is desired. At first thought it would seem as though the solution was accomplished, but, unless the ultimate strength or elastic limit be also specified or the allowable stress be a certain function of the elastic limit, it is not so. Since the elastic limit may vary between 23,000 and 37,000 the final strength will vary in the same ratio even though the stresses do not exceed the specified limit. To reduce the problem to one of a definite shock with a definite elastic limit strength is a great step in the direction of scientific accuracy.

**Vertical Loading.**—Having secured data upon which to base the horizontal loads the next factors to be considered are those acting in the vertical planes of the center and side sills which, combined with the former, denote the size sections which must be used to stand up to the service. The graphical analysis as well as the analytical discussion depends upon a careful selection of these constants for their accuracy.

As a means to definitely determine the value of these constants and thereby secure a just appreciation of the distribution of the weights of superstructure and lading we consider a section of the car, as shown by Fig. 8, a unit in length. The side sill will then each carry the weight of the superstructure one foot long and one-fourth the distributed per foot weight of seat and passenger load.

To determine the weight of the vestibule, which is really a concentrated load on the center sill overhanging the truck center, we have, by assuming—

$W$  = total weight of car body + passengers, allowing 50% for overload in the latter.

$W_1$  = weight of vestibule end.

$b$  = distance between end sills.

$w$  = uniform weight per foot length.

$$W = 2W_1 + wb$$

$$\text{or } W_1 = \frac{W - wb}{2} \dots \dots \dots (1)$$

Therefore, for ease in securing the constants necessary in determining the existing stresses and the proper distribution of the various loads, we have endeavored to show in Table I. all the cars, both steel and composite, that have appeared in the various technical papers from the time this form of car made its first appearance up to the present. It was found necessary, owing to the wide range of service and peculiarities of design both in center and side sill construction, to compile the properties of these designs for comparison, as to strength and stiffness.

From the seating capacity and weight of car body, if for passenger service, and from the weight of car body and capacity for baggage, the various loads per foot of length are found to be as follows for the various vehicles:

For Electric Service:

$w = 950$  lbs.

For Steam Service:

$w = 1,325$  lbs. (Passenger).

$= 1,400$  " (Dining).

$= 1,500$  " (Sleeper).

$= 1,600$  " (Baggage).

The above constants, which are a mean of the various vehicles, can be used in determining the weight of car body plus a 50 per cent. passenger overload when the length over the buffers is used as a multiplier. They should neither be used in an assumption for determining the weight of the car body proper, between end sills, nor in ascertaining the weight of overhanging vestibule load, the former of which, namely  $w$ , as noted in the following paragraph is higher and the latter lower per foot than the value tabulated.

As a means in securing this data we have made a few assumptions: 1st, that the weight of vestibule equals 5,400 lbs., which value when substituted in equation (1) will give the uniform

weight per foot of length somewhat higher than those given, the latter of which should be used.

Our second assumption is that the center sills take 550 lbs. per foot length, while the side sills take the difference between the above weight and the constant found by our first assumption, which we found to be 1,380 lbs. per foot of length; this would give the side sills 830 lbs. or 415 lbs. per foot of length each. These values then we intend to consider in following calculations.

#### Trunk Line Accommodation Service.

This branch of main line operation offers a more inviting field for the use of electricity than the express service. There are some roads already running electric trains over the existing steam right of way with success. To reach its greatest development trains should be run at shorter headway and by making the schedules attractive increase the patronage to a paying degree. This can be done, though it will be a difficult matter when thus run upon a busy steam (express) line to keep the services from interfering. There is a great probability that some time in the future the accommodation service will be run on separate tracks with electricity as a motive power. This service naturally runs

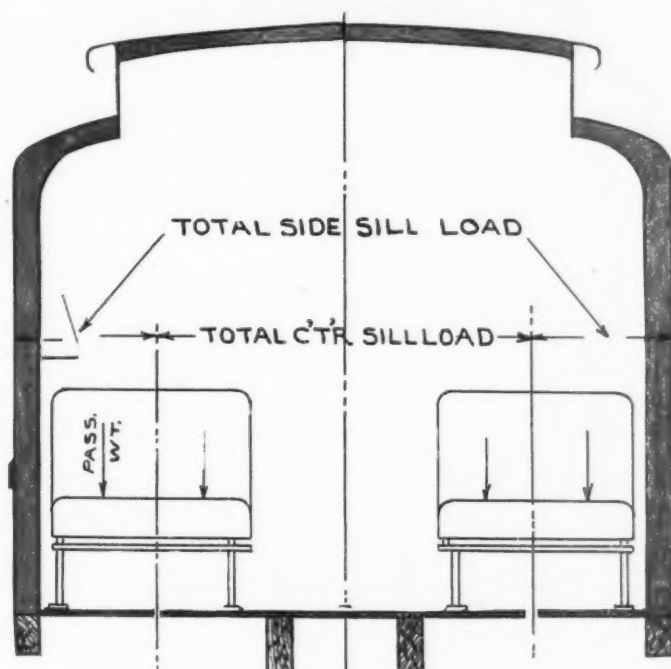


FIG. 8.

much into the province of what is properly known as suburban running, with the advantage that the travel is, as a rule, neither so congested nor so periodic. The disadvantage holds that they must have their framework designed to take the same shocks and loads as the express service if they use the same right of way, otherwise they can be built according to the data covering the suburban equipment.

#### Suburban and Metropolitan Service.

This service with few exceptions merits the consideration of a probable use of multiple unit train control and its effect upon the framing. Here the problem is much different since the cars, because of the character of the traffic, which is periodically congested, must be made lighter and shorter and capable of quickly discharging their passengers and filling up again. Tunnels, subway and surface lines running trains through cities and into terminals at short headway with numerous stops are being compelled to electrify. Here it can be economically accomplished.

This class of service must have an underframe which is elevated sufficiently to allow the placing of motors underneath the sills which for the larger class of machines means from 40 to 41 inches. The depth of the underframe is thus restricted, since it is not advisable to have the floor more than 53 inches above the rail. This limitation is not a serious difficulty, since the character of the shocks from the service imposed are not so severe. For steam or electric locomotive service this follows from the

lightness of the equipment and it is much less for individual car control. Also the probability of an encounter with heavy fast moving freights is more remote. The end shocks in such service will not total more than 80 per cent. of those for express running, so that the value of 500,000 pounds should be replaced by 400,000 pounds and the elastic limit strength, together with the necessity of keeping the total stresses within it, will apply to suburban equipment the same as for express.

It is very desirable that throughout all these types of equipment the principles of uniformity, making for extensive interchangeability and standardization be kept well in view. These will be felt in a manner least thought of, that of increased safety to the public; since the facility with which repairs can be made makes it certain that they will be taken care of promptly and before an accident occurs. This idea has been expressed as applying to electric motor cars, but is true of every class of equipment.

The weight of 950 pounds per foot, which is an average of cars now built including vestibules and lading as noted before, should be used in calculating  $w$  for designing this type of car. The vestibule weights will be as high as for the express due to the increased length necessary to properly handle the traffic with the minimum loss of time at station stops.

The separate center and side sill weights should be the same portion of 950 as 550 is of 1,325, which we find to hold good for express service.

#### General Discussion of Underframe.

The design of car framing has been likened to and in many cases is made a problem of bridge engineering pure and simple. This is a fallacy at the present day; there was a time when cars were intended for separate running at slow speeds when the forces necessary to be considered were simply those of the dead load of the car body and the live loading of passengers and baggage. The basis of calculation was then found in these weights carried; now the strains from service handling introduce stresses beyond what these former forces will reach and the problem is modified accordingly.

The superstructure cannot be made of a strength equal to that of the underframe and keep within the prescribed limits. It must withstand, however, the stresses occasioned by the inertia forces during coupling or braking. It must be a slightly elastic enclosure capable of being rolled over without collapse; and though yielding to a very small degree, it must not bind windows and doors under service conditions.

The framing then should not be dependent upon the roof and side plates for strength, but the functions of these details should be for finish and an aid to the preservation of post and carline alignment. Truss rods as well as any other tying liable to entanglement in wreckage should be done away with and the sides made strong enough to be load carriers between transverse supports. These transverse supports should be placed so that the weights of the superstructure and lading are transferred to the center sills so as to fully utilize the metal in them necessary for buffing. The underframe should, first of all, then be composed of centrally located longitudinal resisting bodies in a single column form, which is strong enough to prevent any relative displacement of its ends under ordinary service conditions.

The side girder construction designed for load carrying is not of a character suitable for end shock absorption. In order that these girders should help in this service it would be necessary to have an end construction which rigidly connects the ends of all longitudinal stringers together, which is a matter of great difficulty. This end construction to transmit the end load to the side girders must have no appreciable deflection and then at its best would apply this strain at a large eccentricity. This means that the first effect would be to dangerously stress the girder in a vertical plane if it were heavily loaded already and the cross ties were strong enough and properly placed. The sides as a rule are heavily loaded and the ties are not right for this use. To satisfactorily serve such a purpose these ties between center and side sills would have to be capable in both tension and compression; they must be attached to the sills with great care so

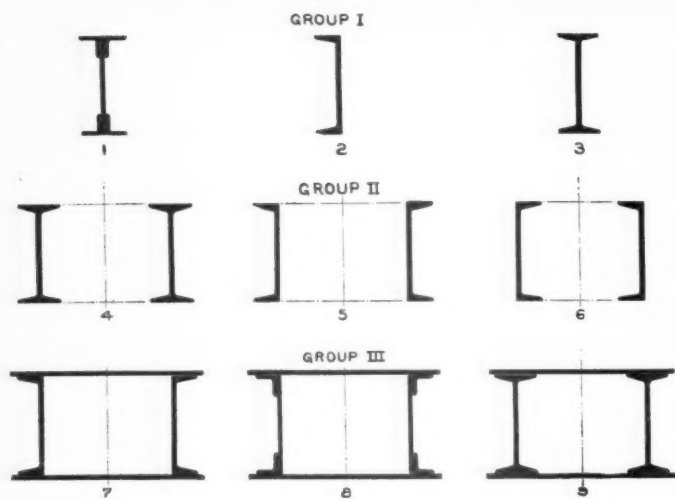


FIG. 9.

as to avoid the creation of eccentric secondary stresses; their end attachments must be rigid at both center and side sills; and they must be placed close enough together to reduce the section of sill between them to the condition of a pure compression piece.

These conditions are not possible of fulfillment with a low weight and the center sills should be considered as taking all of the service end shocks. Thus the center sills should be of the most economical form for compression members. This member must sustain a uniform flexural load, an eccentric end shock and, depending upon whether the center or side sills are load carriers, various concentrated loads at the transverse cantilevers.

The economical form of such a member depends upon the cost of the material and the manufacturing of that material into the shape most suitable to the detail design. More than all else does the economical form of this column depend upon its stiffness and efficiency as a strut. From an examination of column formulae it is easily noticed that this efficiency is governed by the radius of gyration of the given section when the lengths and end construction are given and that, "the greater the least radius of gyration the less the required area." The ratio between these radii for the sections illustrated in Fig. 9 are as 2, 3 and 4 for the 3 groups respectively. The value of the cover plates to take up the bending moments produced by an eccentric application of the load can not be neglected. When the stiffness and strength of the center sills in their capacity as a beam with overhanging ends is considered the value of the sections in group III. is further emphasized.

Consider two center girders of equal area and equal weight. If the moment of inertia and modulus of resistance be unity for the sections in group II., they will be more than three times as large for those of group III.

Thus for a given weight an underframe is but little more than  $\frac{1}{3}$  as strong as it should be when formed of simple I and channel sections.

The change from wood to steel as a constructive element is a measure destined to broaden the limitations surrounding car design. With wood these bounds are evidenced by the inability of providing a sufficiently strong and light central backbone to which can be transmitted the outer lading for our longer cars.

The three following ratios have been frequently used to show that for equal weights steel and wood are of equal strengths:

1. Ratio of weights	Steel	489.6	12
	Wood	38.68	1
2. Ratio of crushing strengths		55,000	11
		5,000	1
3. Ratio of tensile strength		55,000	8
		7,000	1

Did we have the space necessary it would be impossible from the standpoint of dead weight and economy to place wooden

stringers of a depth or breadth to equal the reliability of such center sills as the most reliable noted in Table I.

These ratios would indicate that for tension only, to secure an equal strength we would need but  $\frac{1}{4}$  the weight of wood as of steel while for compression the weights should be approximately equal.

These results can be accepted as holding only where the disposition of the material is the same in both cases, but when a change to a more efficient material is made the field of possible arrangement alters the matter so that, by properly disposing the material into the form of commercial shapes and utilizing plates to form box girders, a marked increase in strength is secured without a corresponding increase in weight. This is especially true when the depth is limited as in the case under consideration. When the limitations governing the physical form in which wood can be used and its fixed strength are considered, it does not then suffice to say that equal weights provide equal strength.

The vertical plane couplers seem to be unable to preserve the proper alignment of the platforms and so the post connections for the end of the car with the underframe, must be of sufficient strength to enable the one car to resist the tendency of its being telescoped by the ram on the end of the overriding platform. These rams (end castings or other steel construction) should also be formed large enough to prevent a partial side telescope in the event of the couplers breaking and the transverse alignment being destroyed. They should also be so shaped that their form tends to throw one car out of range of the other in the case last mentioned.

The attachment of the draft gear is a detail which merits careful consideration. Its location with reference to the neutral axis of the center sills has a great bearing upon the stresses occasioned by the shocks transmitted through it. These stresses can be much increased or diminished by the disposition made of the draft gear or, since the height of the coupler is fixed, by the relative positions of the (axes of the) imposing and resisting forces.

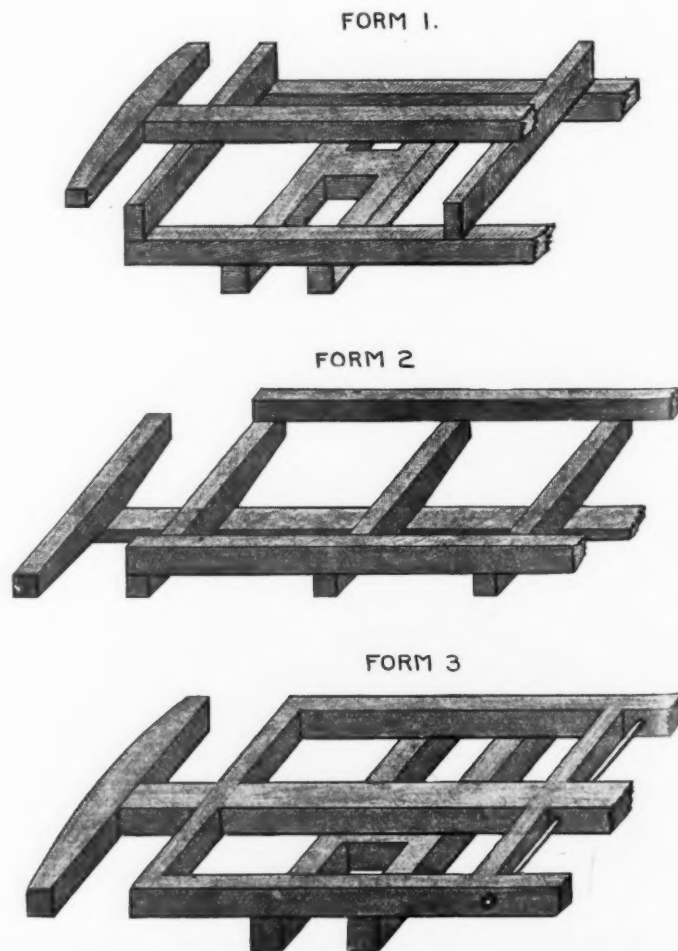


FIG. 10.

### Arrangement of Underframe Members.

The strains which are liable to be imposed upon the underframe having been determined, the next step is to enquire into the possible methods of transferring these forces to the center-plates. The necessity for strong center sill construction for pulling and buffing has been dealt with in general as well as the impracticability of creating side girders to help sustain such forces. There remains to be considered the carrying of the live and dead loads. Starting at the center plate it is evident that it may receive its load: first, directly from the side sills; second, directly from the center sills; third, from both center and side sills.

The three perspective forms as illustrated, Fig. 10, are intended to clearly show the essentials of these three classes of load transference. They do not purport to show any detail design. Theoretically the first form is not found in practice as it would mean that there were no center sills whatever and that the whole superstructure and floor loads were transferred to the side sills and thence through the bolster to the center plate. The practical working out of this form shows a center sill which is weaker than the side girder and as a result, is in effect hung up to the sides at intermediate points between and beyond the bolster. Then the bolster gets all its load from the side sills, with the exception of the center floor load in the immediate bolster vicinity. The bolster with weak center sills is then the governing feature of this form.

The second form is readily known by the absence of any bolster. This is its distinguishing characteristic. In this case the static loading is all transferred at various intermediate points to the center sills which in turn put it directly upon the center plates which are riveted to them. This type presupposes a strong center sill and may make use of a weaker side girder. There is but one road so far as we know using this form of under body.

The third form is characteristic of a majority of all the equipment in service. Here all sills carry load to a bolster.

In all of these forms the side sills should be capable of sustaining the load between their transverse supports. These forms are quite general and are susceptible of much change so that the one seems to overlap the other. This confusion is readily cleared away when the relative stiffnesses of the side and center girders are known for the load they are to carry respectively.

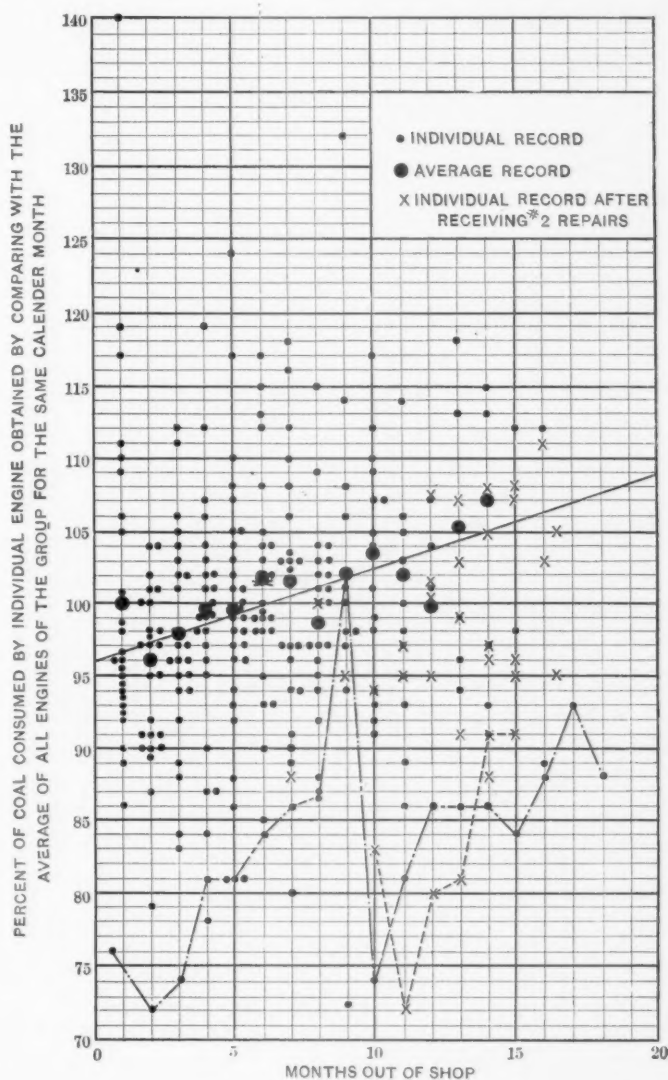
The second form lends itself particularly to those cars which have side doors such as the postal and the baggage types. A support may be placed directly under the aperture for load transference to the center sills and the side will not need to be strengthened by fish-bellied sills, truss rods, or a framed construction carrying the strain up to the eaves and over the door. The advantage accruing from the most improved ideas of interchangeability and standardization would argue that the same construction for these reasons, if for no others, should be followed in all equipment. For end shocks up to one-quarter of the assumed maximum it is possible to construct the first two forms of cars at about the same cost. When the end shocks reach a higher figure and approach 400,000 to 500,000 pounds the center girder of the first form must be increased considerably beyond what would normally be required. There is then a surplus of material in this form, when designed for heavy duty, beyond what the service warrants and this fact makes the first more expensive than the second form.

### THE EFFECT OF AGE ON THE COAL CONSUMPTION OF LOCOMOTIVES.

The accompanying diagram considers the fuel consumption of a group of 20 cross compound, ten-wheel, freight locomotives on the Canadian Pacific Railway, showing how it is affected by the length of time the engines have been out of the shop. The ordinates indicate the number of months the engines have been out of the repair shop. The engines were, of course, turned out of the shop at different times during the year, and to gain a fair comparison and eliminate the effect of weather and other varying conditions the fuel consumption of each engine has been compared each month with the average fuel consumption of the engines in the group. These percentages have been plotted, as

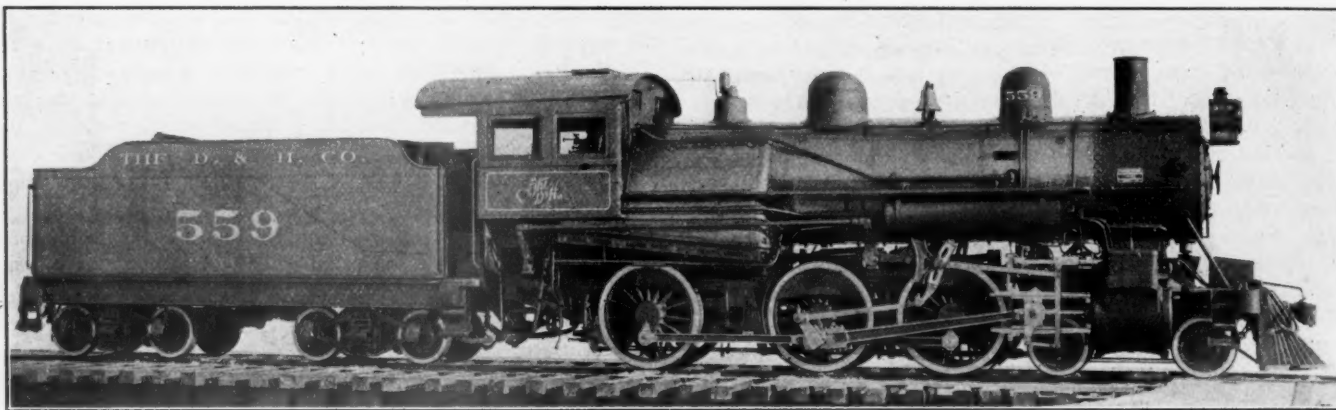
shown, the larger dots indicating the average or mean for all the engines. The X marks indicate that the engines have received what is known as No. 2 repairs, or a light overhauling. Where two or more engines have the same percentage for the same month out of the shop, one is placed on the ordinate, the second and third immediately to the right or left of the ordinate, and the fourth or fifth, if there be that many, just below or just above the first one.

It will be seen that the fuel consumption for the first month out of the shop is high. It drops the second month, and in general advances from 96 or 97 per cent. the second month, to above



105 per cent. at the end of the fifteenth month out of the shop. The dots which are connected by the dot and dash lines indicate the comparative performance of engine 1000, a ten-wheel, cross compound, fitted with a Schmidt superheater. This engine ran for a period of 18 months between shoppings, but for some reason the comparative fuel consumption was very irregular between the eighth and twelfth months. The supplementary diagram for this engine, indicated by the X marks, connected by the dotted lines, was for a period immediately preceding that when the engine previously received general repairs, although at the tenth month, when this part of the diagram commences, it had received a light overhauling. We are indebted to Mr. H. H. Vaughan, assistant to the vice-president, for this information.

NEW STATION AT WASHINGTON, D. C.—The new passenger station at Washington, D. C., built jointly by the Baltimore & Ohio Railroad and the Pennsylvania Railroad, was opened on October 27. This is one of the finest, if not the finest, in the United States, and is 632 ft. long, 210 ft. wide and 120 ft. high in the main waiting room. The train shed contains 33 tracks.



CLASS D-3-B LOCOMOTIVE, WITH CAB BACK OF FIREBOX—DELAWARE &amp; HUDSON CO.

## TEN-WHEEL LOCOMOTIVE FOR GENERAL SERVICE.

DELAWARE &amp; HUDSON COMPANY.

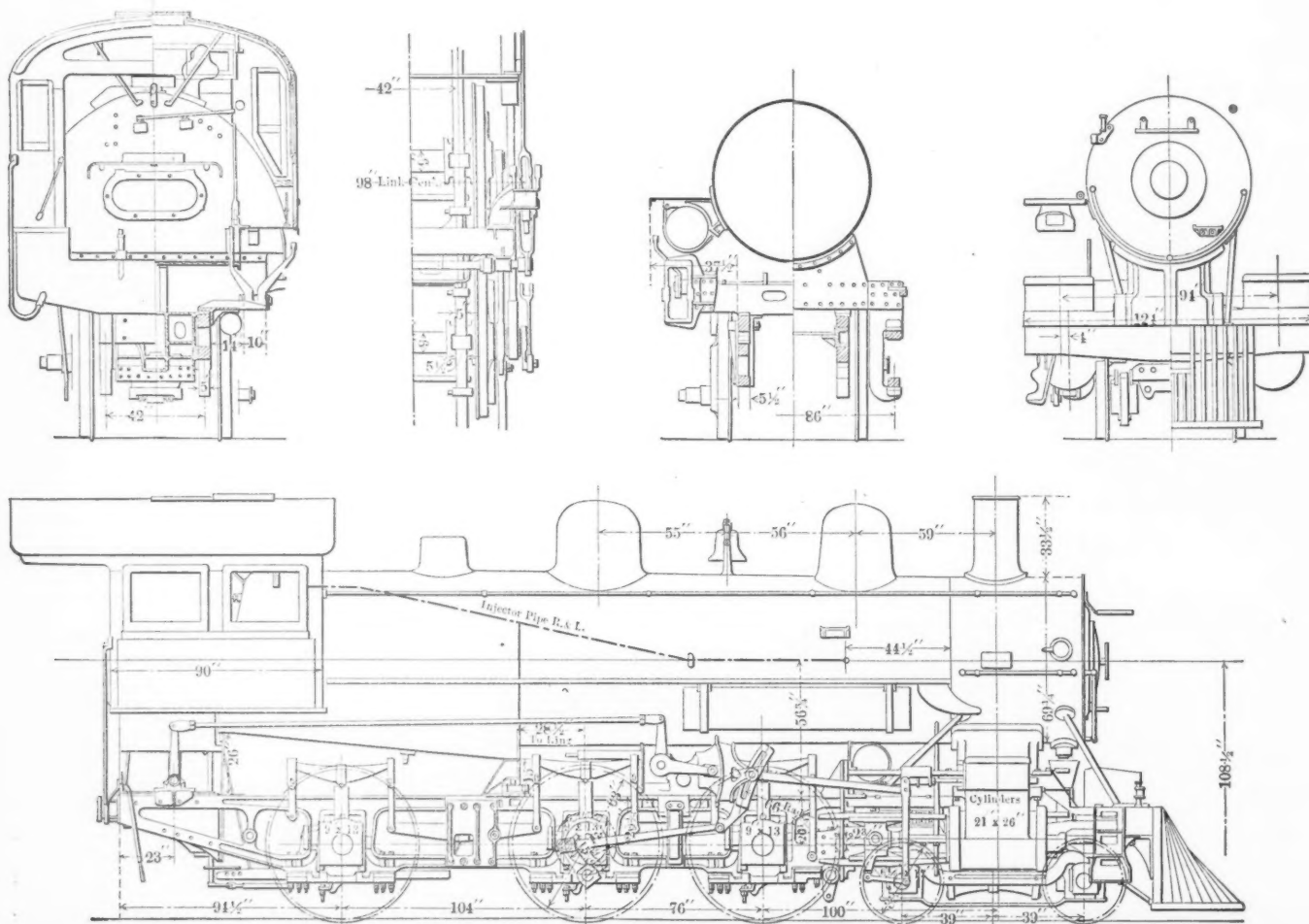
The motive power of the Delaware & Hudson Company consists very largely of locomotives of the consolidation type, among which are the largest and heaviest locomotives of this type in the world. These engines, of course, handle all of the heavy slow speed trains, which form a very large part of the traffic. The lighter passenger trains are handled altogether by the 4-4-0, or American type, of which there are 77 in service. The remainder of the locomotives are divided between the 2-6-0 type, all of which were built before 1900, the 4-6-0 type and the switching types. The first two of these classes, the former of which has now been abandoned in new construction in favor of the latter, are used for the lighter freight and heavy passenger service.

The ten-wheel, or 4-6-0, type, which is known in the road classification as Class D-3, was introduced on this road in 1903,

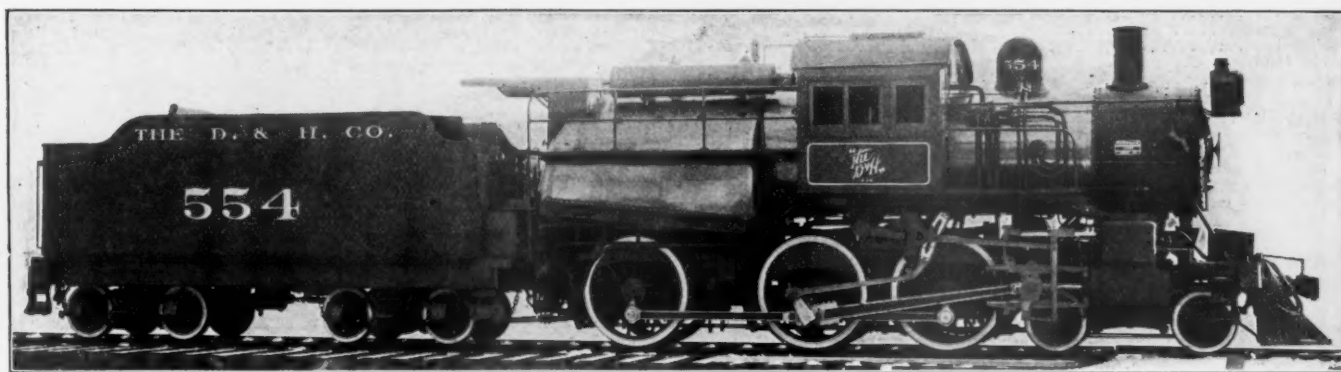
by the delivery of an order of four locomotives from the American Locomotive Company. These engines had 21 x 26 in. cylinders, 72 in. drivers and a total weight of 175,000 lbs. This number was further increased by five locomotives of the same design

Road	D. L. & W.	D. & H.	C. & N. W.	C. P. R.
Total weight, lbs.	201,000	189,000	179,500	190,000
Weight on drivers, lbs.	154,000	143,000	135,500	141,000
Wgt. driv. ÷ total wgt., %	76.5	75.7	75.7	74.2
Tractive effort, lbs.	35,100	30,900	30,900	33,300
Diameter drivers, in.	69	63	63	63
Cylinders, in.	21½ x 26	21 x 26	21 x 26	21 x 28
Steam pressure, lbs.	215	200	200	200
Total heating surface, sq. ft.	3,378	2,582	2,959.2	2,413
Grate area, sq. ft.	94.8	84.9	46.27	49.5
Tractive effort, ÷ heating surf.	10.4	12.	10.4	13.8
Total weight ÷ heating surface	59.8	73.	60.5	78.5
B. D. ratio.	717.	750.	655.	870.
Heating surface ÷ cyl. vol.	311.	250.	287.	215.
Reference in AMER. ENG.	1905 p. 407		1907 p. 247	1906 p. 165

built in the shops of the company. These were followed in the next year by the class D-3-A, which have 21 x 26 in. cylinders, 69 in. drivers and weigh 174,000 lbs. total. There are four engines in that class. In 1905 and 1906 the first of the class D-3-B,



ELEVATIONS AND SECTIONS OF TEN-WHEEL LOCOMOTIVE WITH CAB BACK OF WOOTEN FIREBOX—D. &amp; H. CO.



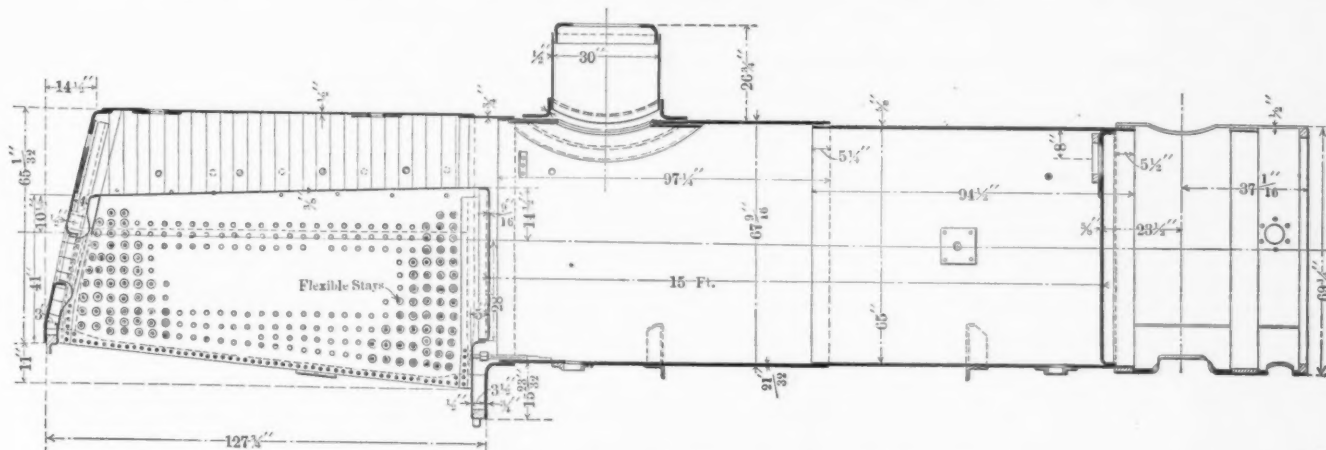
CLASS D-3-B LOCOMOTIVE WITH CAB AHEAD OF FIREBOX—DELAWARE &amp; HUDSON CO.

which have 21 x 26 in. cylinders, 63 in. drivers, and weigh 173,000 lbs., were built at the company's shops, there being 10 in that order.

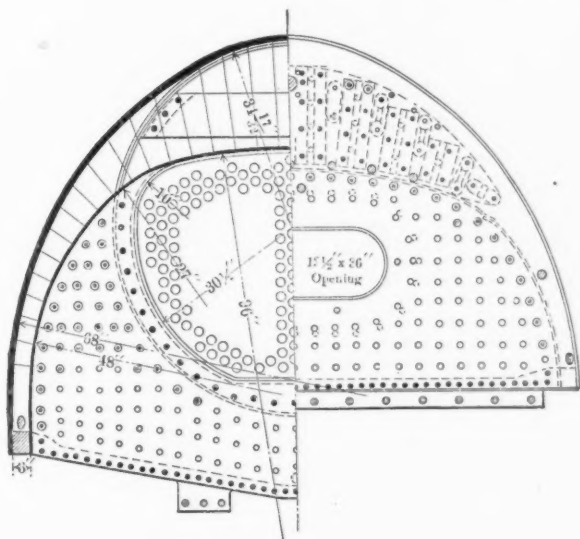
This number has recently been increased by the delivery of fifteen from the American Locomotive Company, which differ from those built at the Company's shops by having the Walschaert instead of the Stephenson valve gear and in a few other details, which brings their weight up to 186,500 lbs. Of this

of the fire box. This has proved to be an advantage and the same alteration is being made in an order of 30 consolidations now being built.

The accompanying table permits the comparing of these locomotives with a number of other recent ten-wheel designs, and in studying this table it should be remembered that the Delaware, Lackawanna & Western and the Delaware & Hudson locomotives burn anthracite coal while the other two use bituminous fuel, and



SECTIONS OF BOILER—DELAWARE &amp; HUDSON TEN-WHEEL LOCOMOTIVE.



order of fifteen, two were built with the cab located at the rear instead of in front of the fire box, as has usually been the case with the Wooten type of boiler. This change has increased the total weight to 189,000 lbs. and the weight on drivers from 134,000 to 143,000 lbs.

The change in the location of the cab on two of these engines has been made for the purpose of keeping the engineer and firemen together, which of course is impossible with the cab ahead

also that the Canadian Pacific locomotive is equipped with the Vaughan-Horsey superheater, both of which differences affect the ratios concerned with the heating surfaces.

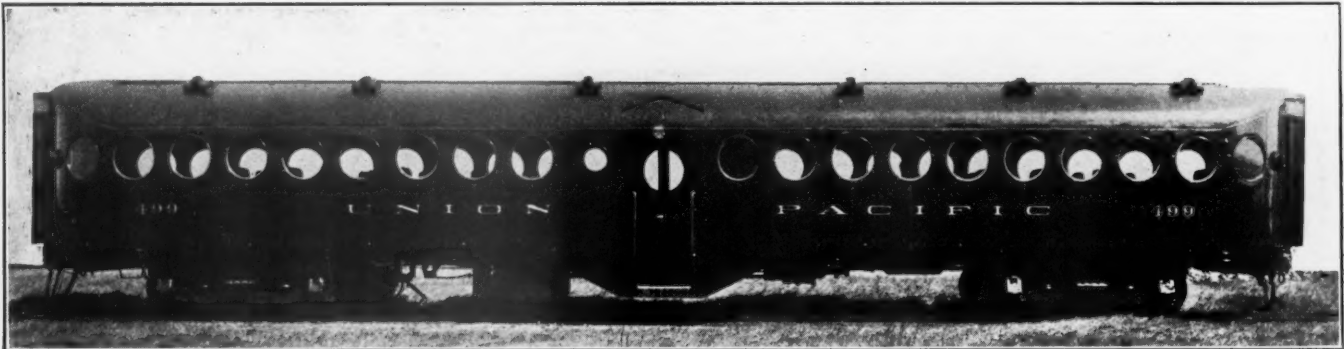
The illustrations show the construction of the boiler and machinery. It will be noted that the I-section cast steel frame, which is standard on the Delaware & Hudson, is used in this case. In other respects, however, there is nothing unusual in the design. It was of course necessary to extend the reach rod outside of the fire box, which places it very close to the clearance limits. In the design of the boiler a liberal use of flexible stays in the breakage zones and the O'Connor fire door flange will be noticed.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8 1/2 in.
Service	Freight
Fuel	Anth. Coal
Tractive effort	30,900 lbs.
Weight in working order	189,000 lbs.
Weight on drivers	143,000 lbs.
Weight on leading truck	46,000 lbs.
Weight of engine and tender in working order	331,700 lbs.
Wheel base, driving	15 ft.
Wheel base, total	26 ft. 6 in.
Wheel base, engine and tender	59 ft.
RATIOS.	
Weight on drivers ÷ tractive effort	4.63
Total weight ÷ tractive effort	6.10
Tractive effort X diam. drivers ÷ heating surface	750.00
Total heating surface ÷ grate area	30.50
Firebox heating surface ÷ total heating surface, per cent.	6.90
Weight on drivers ÷ total heating surface	55.00
Total weight ÷ total heating surface	73.00
Volume both cylinders, cu. ft.	10.40
Total heating surface ÷ vol. cylinders	250.00
Grate area ÷ vol. cylinders	8.15
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 X 26 in.

VALVES.	
Kind .....	Bal. Slide
Greatest travel .....	5½ in.
Outside lap .....	11/16 in.
Inside clearance .....	0 in.
Lead, constant .....	3/16 in.
WHEELS.	
Driving, diameter over tires .....	63 in.
Driving, thickness of tires .....	3½ in.
Driving journals, main, diameter and length .....	9 × 13 in.
Driving journals, others, diameter and length .....	9 × 13 in.
Engine truck wheels, diameter .....	38 in.
Engine truck, journals .....	6½ × 12 in.
BOILER.	
Style .....	Improved Wooten
Working pressure .....	200 lbs.

Outside diameter of first ring .....	66¼ in.
Firebox, length and width .....	119¾ × 102 in.
Firebox plates, thickness .....	¾ and 9/16 in.
Firebox, water space at mudring .....	3 and 3½ in.
Tubes, number and outside diameter .....	308—2 in.
Tubes, length .....	15 ft.
Heating surface, tubes .....	2403.1 sq. ft.
Heating surface, firebox .....	178.9 sq. ft.
Heating surface, total .....	2582 sq. ft.
Grate area .....	84.91 sq. ft.
Smokestack, diameter .....	18 in.
Smokestack, height above rail .....	14 ft. 8½ in.
TENDER.	
Wheels, diameter .....	33 in.
Journals, diameter and length .....	5½ × 10 in.
Water capacity .....	6860 gals.
Coal capacity .....	13½ tons



ALL-STEEL PASSENGER COACH WITH CENTER DOORS—UNION PACIFIC RAILROAD.

## ALL STEEL PASSENGER COACH.

UNION PACIFIC RAILROAD.

The most recent introduction of steel into the construction of railway rolling stock by the Union Pacific Railroad has been made in the building of an all-steel, fire-proof passenger coach, which has recently been turned out of the Omaha shops and placed in service between Omaha and North Platte.

This coach bears very little semblance to the ordinary passenger coach, and has been constructed on entirely new lines. The upper deck and sashes have been replaced by a semi-circular roof, similar to that of Union Pacific gasoline motor cars. A reduction of twenty-four inches in the distance from rail to roof is thus accomplished. The ends of the coach are also made circular for the purpose of reducing the wind resistance and the rectangular sash and gothic window frames are displaced by round metal sash 24 in. in diameter, which form absolute dust and water-proof windows.

The most noticeable departure from common practice in wooden car construction is the absence of steps and vestibules, the steel coach being equipped with two side door entrances in the center. The car also has a door at each end forming a passage-way to other cars.

A remarkable feature of this car is the thickness of the walls, which are only 2 in. from outside sheathing to finished surface of interior wall, a reduction of 3½ in. over the present wooden, or any fire-proof coach ever constructed. This affords an additional clearance of 7 in. in the aisles and adds materially to the comfort of passengers.

The underframe of the car consists of two 12 in. I-beams set at 16 in. centers, which act as center sills, and 6 × 3½ in. angle iron side sills. These longitudinal sills are continuous and are framed into large steel castings measuring 11 × 9 ft., which include the double body bolster, end sills and end bracing in one piece. The center sills are inserted only to carry the pulling and buffing stresses and do not carry any of the load of the car or its lading.

The side posts and carlines are in one continuous piece of 3 in. channel iron, which is bent into the form of a letter U and

extends continuously from side sill to side plate, thence over the roof and down to the side sill on the opposite side. These posts are set with the web of the channel parallel with the side sills.

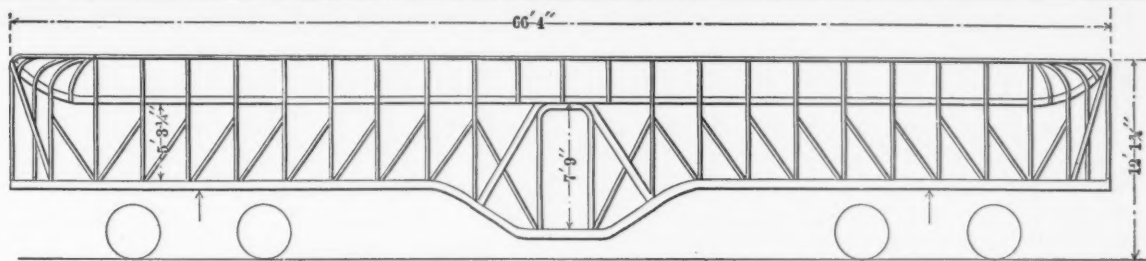
The side plate of 4 in. channel iron is attached to the side posts at the eaves and acts as the upper chord of the side girder the web of which is formed by the ⅝ in. steel side sheathing and the lower chord by the side sill. The posts act as stiffeners and a number of diagonal braces placed below the windows are inserted for further stiffness. All of this construction is thoroughly riveted together. Holes 25 in. in diameter are cut out of the sheathing and in this are inserted the aluminum frames



INTERIOR OF UNION PACIFIC STEEL PASSENGER COACH.

for the circular windows. The end framing is similar to that used on the sides, being formed of the same size and shaped parts, which are framed and riveted to suit their respective locations.

A 1/16 in. steel plate is riveted over the underframe and upon this is a layer of ¾ in. hair felt. Above this the flooring of fire-proof composition in pressed sheets ½ in. thick is laid on nailing strips embedded in the felt. Stove bolts, with heads flush with

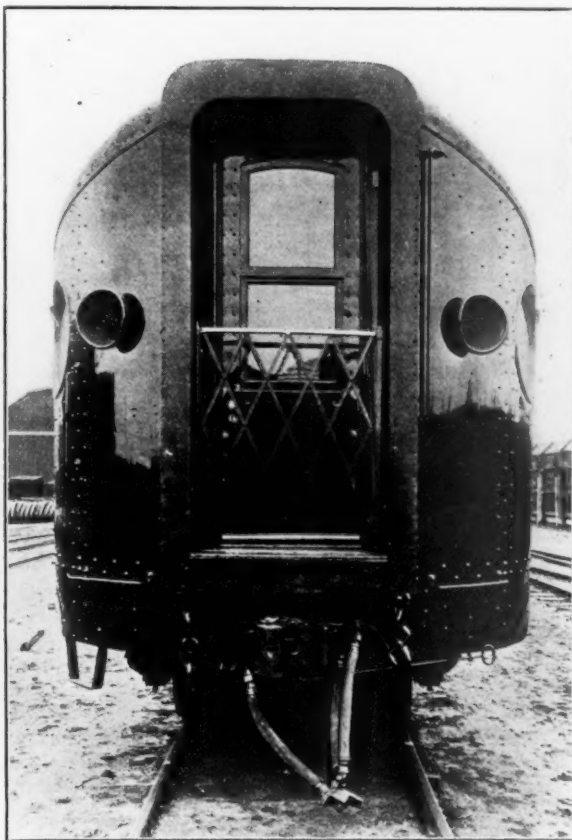


OUTLINE DIAGRAM OF FRAMING—UNION PACIFIC STEEL COACH.

the floor, fasten the floor construction together. The only wood used in the construction of this car is in the shape of filling blocks, there being altogether about 200 lbs.

The circular windows are equipped with an aluminum sash in which is fitted a 24 in. glass. This sash is hinged at the top and a special window catch is provided for holding them in a horizontal position when swung up. A half round rubber gasket is fitted between the frame and the sash and forms an absolutely weather and dust proof joint.

Special attention has been given to the ventilation of this car and Cottier suction ventilators of an improved design are placed at intervals on the roof on each side of the center line of the car. These draw out the bad air. Fresh air is admitted through the circular openings seen in the end view of the car, which are located about 8 ft. from the rail and are 12 in. in diameter. They are covered with a fine brass net and connect to a sheet iron conduit placed beneath the floor, and containing two sets of removable dust collecting screens. After passing the screens the purified air is admitted to the inside of the car, along the sides,



END VIEW OF UNION PACIFIC STEEL COACH.

through a galvanized sheet iron duct having perforations opposite each seat. The steam heating pipes are placed along the outside of the air duct and heat the air before it is admitted to the car. Dampers are provided for controlling the amount of fresh air admitted.

The car is lighted by electricity, the current being obtained from a generator belted from the axle. An 8 candle power lamp, with frosted globe, is fitted in the side of the car, opposite each seat, being slightly above a seated passenger's head.

The weight, general dimensions, etc., are shown in the following table:

Actual weight .....	89,300 lbs.
Length over diaphragms .....	68 ft.
Height, rail to roof.....	12 ft. 1 1/4 in.
Height, floor to ceiling .....	7 ft. 8 3/4 in.
Width inside at wainscot .....	9 ft. 5 1/2 in.
Width of aisle between seats.....	3 ft. 5 1/2 in.
Width of car over side sills.....	9 ft. 5 1/2 in.
Roof sheets, galvanized iron.....	1/16 in.
Truck .....	4-wheel cast steel
Seating capacity of coach .....	78

### ENGLISH RAILWAY DYNAMOMETER CAR.

The North Eastern Railway of England has recently completed a dynamometer car designed by Mr. Wilson Worsdell, general mechanical engineer, which contains a number of very interesting features.

The draw bar connects directly to a large flat spring located in about the center of the underframe, which consists of 30 selected steel plates, each separated by rollers so as to eliminate the leaf friction. This spring is 7 ft. 6 in. long, between the centers of the roller stops at the ends, and is enclosed in a dust proof box forming part of the steel underframe of the car. The center band of the spring, to which the draw bar is connected, is supported on a carriage having four wheels resting on polished steel plates. The same band, which is practically part of the draw bar extension, carries a bracket projecting up through the floor of the car and carrying at its upper end a stylographic pen for giving the record of the draw bar pull.

The design and construction of this spring was given the most careful attention and the plates composing it are of the highest quality. Each was separately tested before being put into place and after assembling the spring was very carefully calibrated and found to give a uniform rate of deflection.

The paper driving mechanism consists of a large wheel 3 ft. 9.836 in. in diameter fitted with a very hard flat steel tire and accurately ground to size, which rolls on the rail and can be raised or lowered at will. It is located just inside of one of the trucks. A set of gears is provided for giving different speeds to the paper driving rolls.

The recording table has eight electro-magnetic pens, which can be coupled up through a terminal board as desired and give almost any desired record. A mechanical integrator, consisting of a horizontal, flat, steel plate rotated by gearing from the paper driving mechanism, over which is a frame supporting a small wheel set on edge and connected with the draw bar so as to move across the flat plate at a distance from the center proportional to the pull of the draw bar, is provided. The speed of revolution of the small wheel is a direct measure of the work done and an electrical contact arrangement permits this record to be made upon the roll of paper.

Other instruments in the car show either on dials, or by means of the electro-magnet pens, a permanent record of, the speed, steam chest and boiler pressure, velocity and direction of the wind, time of taking indicator cards, location of curves and permanent objects along the line, brake cylinder, auxiliary reservoir or train pipe pressure, revolutions of the driving wheels, position of the reversing gear, etc.

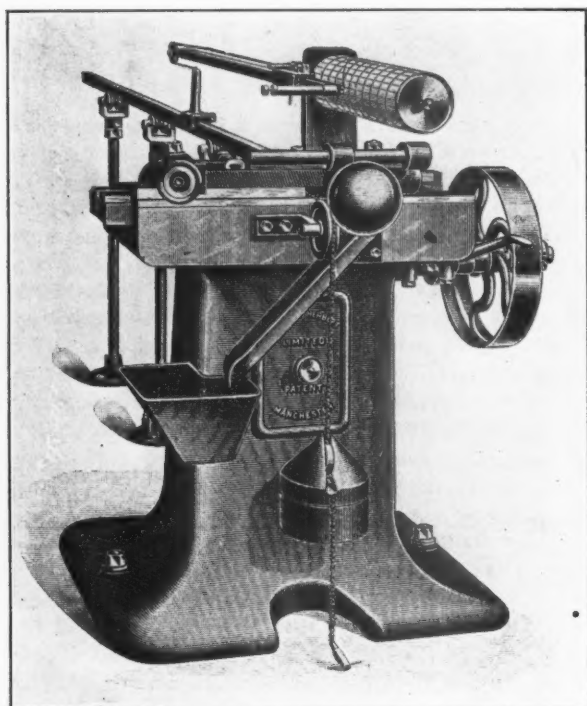
The draw bar connection is arranged with the usual spring draft gear and provision is made for inserting a key so that the dynamometer can be cut out of service if desired. The center of the body of the car is constructed with a shallow bay window on both sides which permits a view to be obtained almost directly ahead, without the opening of the windows.

An illustrated description of this car will be found in the October 4 issue of the *Engineer* of London.

## TESTING FILES.

It is practically impossible to test files accurately by hand. A good file may take 100,000 strokes with little loss of sharpness, while one of poor steel, but well cut, may cut as fast when new, but fail after a few thousand strokes. To ascertain its quality accurately it must be completely worn out in the test. A file testing and indicating machine was invented in England in 1905 and sample files from the leading English and American makers were tested. Some of these were worn out after filing away less than a cubic inch of iron, cutting at a rate of a cubic inch per 10,000 strokes; the best file removed 121 cubic inches of metal, cutting at a rate of 5 cubic inches per 10,000 strokes.

The publication of the results of these tests created a sensation. A public file testing department was established in England and a number of the file makers installed testing machines and experimented with their product to determine the most efficient form of file tooth and the most suitable quality of steel to be used. Files are now made which cut at the rate of 8 cubic inches per 10,000 strokes, and as much as 55 cubic inches have



HERBERT FILE TESTING MACHINE.

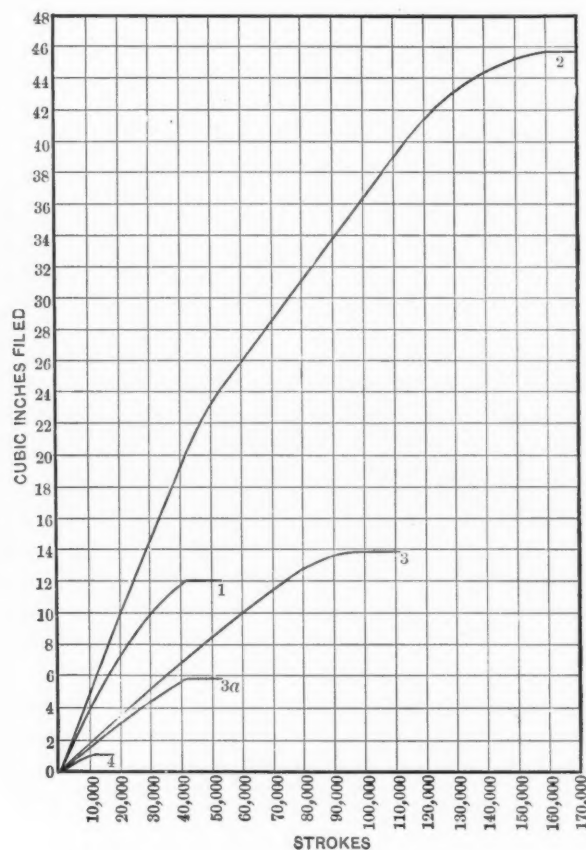
been removed by one side of a single file. The testing machine makes it possible to trace the effect of slight modifications in the manufacturing processes. It also permits the user to order files on a basis of quality and check the files supplied.

The machine, shown in the illustration, automatically tests files of any size from 4 to 16 inches, drawing a diagram which indicates exactly the work done (cubic inches filed away), the sharpness as indicated by the rate of cutting and the durability as indicated by the number of strokes taken before the file ceases to cut. The file is reciprocated against the end of a test bar, which is supported on rollers and is forced lengthwise against the file by means of a weight and chain, giving a constant pressure. The bar is withdrawn during the back stroke. A diagram is made on a sheet of section paper wrapped around a drum, after the manner of a steam engine indicator. The drum is geared to revolve slightly with each stroke of the file, and a pencil connected with the test bar is moved across the paper as the bar is filed away. The result is a diagram showing what the file does every minute during the test.

The diagrams illustrated show the results of tests of four bastard files made by well-known makers and are typical of the large number of tests that have been made. The vertical distances represent the number of inches filed from a standard test bar of annealed cast iron planed to a section 1 in. square. The

ordinates indicate the number of strokes of the file. In each case the files were tested until they ceased to cut, as shown by the diagram. The rate of cutting at any period is shown by the slope of the corresponding portion of the curve. Curve 1 is from a file of good average quality as usually supplied by the best makers. It cuts quickly, but soon wears out, indicating sharp teeth but poor steel. Curve 2 is from one of the new files of modern high class steel with correctly formed teeth. These have been introduced since the advent of the file testing machine. Curves 3 and 3a are from the two sides of another file. Durability was fairly good, but rate of cutting slow, showing good steel but bad teeth. Curve 4 is from a bad file. It will be seen that file No. 2 cut five times as fast when new, lasted 16 times as long, and did 46 times as much work as file No. 4.

Special importance attaches to the rate of cutting because of its bearing on the wages cost of a given quantity of work. The expenditure in files, wages, and establishment charges, incurred in filing away 100 cubic inches of metal with a given make of file



TYPICAL DIAGRAMS OF TESTS OF FILES.

is the best test of its efficiency and is given in shillings by the following formula:

$$C = \frac{L(100 - D)}{I} + \frac{380}{R} \text{ in which}$$

L = list price of a file.

D = discount off list.

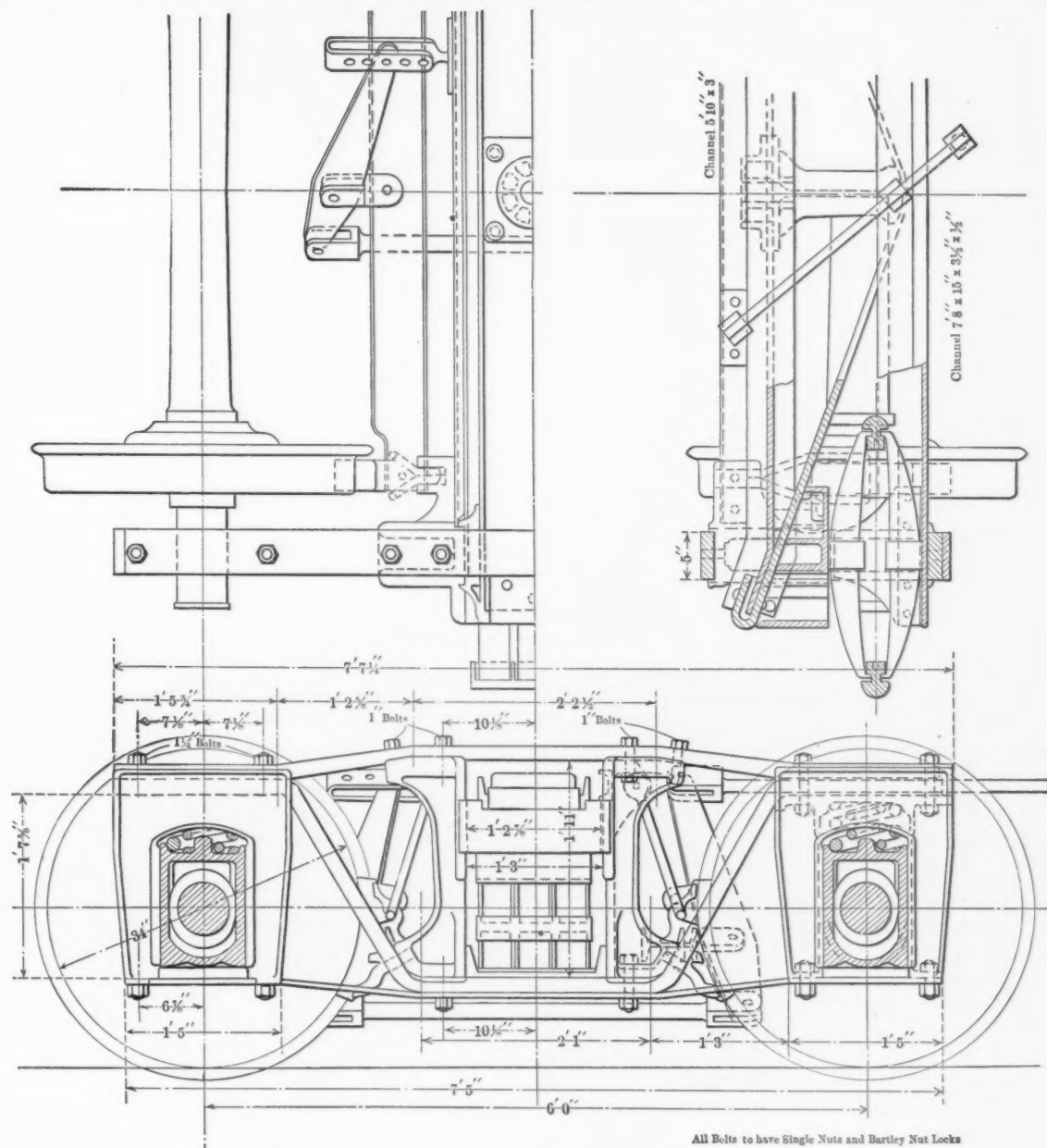
I = total inches filed away by both sides of file (from diagram).

R = mean rate of cutting (inches per 10,000 strokes, from diagram). The formula assumes that the workman is rated at one shilling per hour (wages and establishment charges).

If file No. 2 was sold at 40 per cent. and file No. 3 at 60 per cent. off Sheffield list, the total cost of filing away 100 cubic inches of iron would be: with file No. 2, 4 pounds 16 shillings (\$23.32); with file No. 3, 13 pounds (\$63.18).

Files to be tested should be selected from the lot and should not be "samples." Both sides should be tested as there is often a considerable difference in two sides of the same file.

We are indebted for this information to Edward G. Herbert, Ltd., engineers and machine tool makers, Rosamond street East, Manchester, England, who manufacture the testing machines and make a specialty of testing files for makers and users.



All Bolts to have Single Nuts and Bartley Nut Locks

NEW TYPE OF ARCH BAR TENDER TRUCK—CANADIAN PACIFIC RY.

**TENDER TRUCK.**

CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway is equipping the Pacific type locomotives, which it is building, with a new type of arch bar tender truck. The trucks formerly used were of the ordinary arch bar type and considerable difficulty was experienced due to the breaking of the arch bars, especially the lower ones, during the severe winter weather. Column bolts were also broken and the threads sheared off at the ends due to hard track conditions. To overcome this, and at the same time make an easier riding truck, the design was changed to permit the use of coil springs over the journal boxes. The cast steel column castings, as shown in the illustration, are carefully designed to support or reinforce the arch bars at the bended portions where they usually fail. Short column and journal bolts are used in place of long ones to insure the parts being drawn together more securely and to facilitate repairs. A lug or projection is cast on the column castings from which the brakes are hung. Simplex bolsters are used.

**TIME NOT RIPE FOR GENERAL ELECTRIFICATION.**—Nor does the writer believe that the time is ripe for the electrification of steam roads at large; indeed, the electrical enthusiasts would be hard put to it if called upon to show reason for the electrification of many branch steam lines carrying a small tonnage at in-

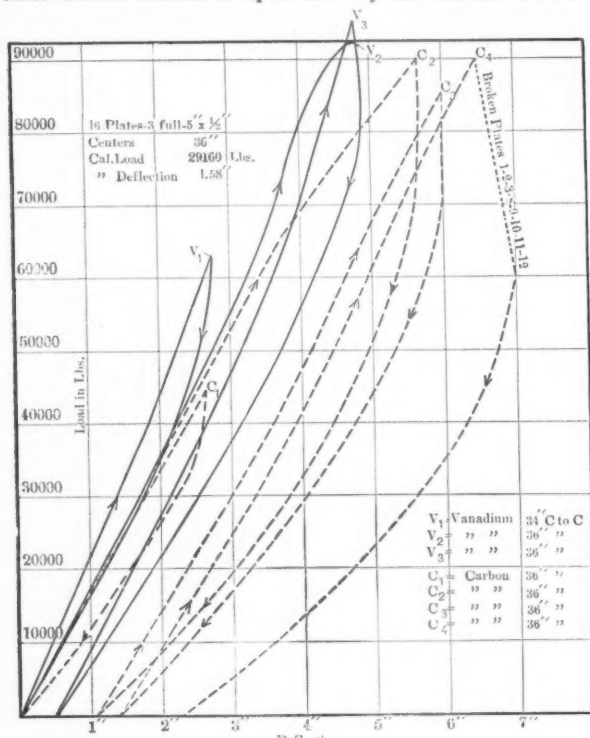
frequent intervals. There are, however, certain divisions of our steam railways which, either on account of their broken profile or heavy traffic, offer an opportunity to introduce a superior type of motive power which will effect such economies in operation as to provide adequate return on the investment required for the electrification. There are still other divisions where a much desired increase in the track-tonnage capacity can only be effected by double tracking so long as the steam locomotive is adhered to as the type of motive power used. Double tracking a mountain-grade division is often a matter of enormous expense, and electrification of the single track may relieve the present traffic congestion at a moderate cost.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

**CLUB HOUSES ON THE SOUTHERN PACIFIC RAILROAD.**—The Southern Pacific Railroad is building a number of club houses at division points along its lines in Nevada, California, Arizona, New Mexico and Texas. These clubs are for the use of employees of all classes and include the usual club facilities and in addition have a number of bedrooms arranged so that they may be darkened during the day. No dues are demanded from members and a very small charge is made for the use of the dormitories and bath rooms. Outside of this, which hardly covers the maintenance charges of these quarters, the railroad company pays all the bills. These clubs are proving to be very popular and are said to be an excellent thing from all points of view.

## VANADIUM STEEL.\*

By MR. J. KENT SMITH.†

When some years ago the statement was recorded that the addition of vanadium to steel strengthened the latter, the asseveration did not appeal much to practical men for many reasons, two of which were: that vanadium was looked upon as an exceedingly rare metal which was quite inaccessible for use in industrial operations, and that the extraordinary properties which vanadium conferred on steel in addition to strengthening it were not even hinted at; in fact, it is only in very recent times that the chief benefit conferred upon steel by the correct addition of



COMPARATIVE TESTS ON VANADIUM AND CARBON STEEL SPRINGS. TESTED BY THE AMERICAN LOCOMOTIVE COMPANY.

The Vanadium spring was tested:  
1. To 62,700 lbs. with 34" centers.  
2. To 92,000 " " 36" "  
3. To 94,000 " " 36" "  
On second test elastic limit was reached at 85,000 lbs. or 234,500 lbs. fibre stress with permanent set of .48".  
The third test was repeated three times without the least variation from recorded heights.  
Type "D," Vanadium Spring Steel.

The Carbon spring was tested:  
1. To 44,000 lbs. with 36" centers.  
2. To 89,280 " " 36" "  
3. To 84,520 " " 36" "  
4. To 89,280 " " 36" "  
On second test, elastic limit was reached at 65,000 lbs. or 180,000 lbs. fibre stress with permanent set of 1.12".  
On third test, it took an additional set of .26", and on fourth test, plates 1, 2, 3, 8, 9, 10, 11, 12 failed at the center.

Static test on piece cut from leaf of spring:	
Elastic limit .....	227,100
Ultimate strength .....	237,500
Ratio .....	96%
Elongation, 2" .....	10%
Contraction of area .....	35%

FIG. 1.

vanadium has been recognized at all, that is, that of endowing it with extreme vitality, or phenomenally high resistance to the fatigue produced by repeated stresses and strains which in the end cause its fracture, although they may singly be below the elastic limit of the metal. Even now this fact has not received the full amount of recognition which it deserves.

Recent discoveries have caused vanadium to pass entirely from the domain of the rare metals to the position of a metal which is readily obtainable in any quantities and at a price which, considering the small proportion necessary to be used, does not put any obstacle in the way of its employment in steels of even a moderately high grade.

An immense deposit of vanadium ore, of a grade which was never hitherto suspected to exist, or even to be capable of existence, has been developed, and is now being worked. Vanadium is commonly alluded to as a rare metal, but this denomi-

tion is correct in a limited sense only. Scientifically the description is entirely inaccurate, as vanadium is one of the most widely distributed of the elements known to us; but in its general forms of distribution it occurs only in such minute quantities as to render any idea of its commercial extraction from such sources utterly impracticable. It is, however, exceedingly rare to find concentrated sources of vanadium in any quantity, so rare, in fact, that the deposit previously spoken of may be reckoned as unique.

It is a silvery white, readily oxidized metal of a very high fusing point. Its alloy with iron, however, in the proportion of approximately two parts of iron to one of vanadium possesses a melting point much below that of steel, and it is in this form that the metal is marketed for the use of the steel manufacturer. No difficulties in its employment are found, provided that reasonable precautions are taken in its addition.

It will be necessary in the first place for me to allude briefly and generally to the micro-structure of the ordinary engineering steels, or such steels as those which are known to metallurgists as "sub-saturated." Carbon is a necessary constituent of all steels, but this carbon is not held in mere solution in the steel nor is it disseminated in the steel in an elementary condition. The ground work of the steel may be said to consist of a carbonless iron of a greater or less degree of purity, and the properties of different forms of this carbonless iron, and their structure both from an intercrystalline and intracrystalline point of view, must first be considered both chemically and physically. Such carbonless iron is known generically as ferrite. In the steel the carbon itself is combined chemically with another proportion of iron forming the chemical compound carbide of iron, a molecule of which contains three atoms of iron and one atom of carbon. This chemical compound alloys itself with more carbonless iron, each molecule taking to itself twenty-one more atoms of iron to form the eutectoid known as pearlite. The particles of this pearlite alloy are distributed in pieces of greater or less size through the main ground work of ferrite, their size, distribution, etc., varying according to the last heat put upon the steel under "work," the rate of cooling, and so forth. From the foregoing it will be seen that, having careful reference to atomic weights, etc., a steel containing .89 per cent. of carbon would completely consist of pearlite, there being no excess of carbonless iron; such a steel would be called "saturated." If the carbon percentage exceeds this amount there would be an excessive quantity of carbide of iron over that required to form pearlite, and this steel would be called "supersaturated." But only the subsaturated steels interest us at present from an engineering point of view.

It has already been said that vanadium is a readily oxidizable element. Amongst the metals it stands very high on the list with regard to its avidity for oxygen; so great is this avidity that under suitable temperature conditions it will decompose the oxides of iron and manganese. It is within the province of the steel-maker to insure the practical absence of these oxides by normal means, but the addition of vanadium insures the complete elimination of the last traces, thereby ridding steel of one of its most dangerous poisons. As their removal is effected by conversion into a light and readily fusible oxide of vanadium which immediately passes into the slag, no danger of the "dryness" attending the use of some deoxidizing agents is encountered. But even more important is the fact that vanadium also eliminates combined nitrogen in the form of a stable nitride.

Aside from the benefits derived from the cleansing action of vanadium (which work be it noted is accomplished at the expense of the ultimate vanadium content of the steel) there are many other points to be observed. The solid solution of vanadium in ferrite causes this ferrite to become much tougher from an intracrystalline point of view, and furthermore promotes the close interlocking of these crystals. Incidentally the ferrite crystals in themselves become somewhat stronger from a purely tensile point of view.

The main practical application of this fact lies in the employment of vanadium in steel castings. It will, I think, be generally admitted that the great majority of castings fail in service through their inability to withstand the disintegrating effect of

\* From a paper presented before the Railway Club of Pittsburg, Sept. 27, 1907.

† Chief metallurgist, American Vanadium Company.

repeated stresses rather than to any original want of static strength and ductility. This lack of endurance cannot possibly be gauged by any static test.

Further, vanadium ferrite offers greater resistance to the passage through it of carbides than does plain ferrite, thus rendering the vanadium steels particularly suited to the great improvements conferred by judicious tempering, while it furthermore renders the tempering limitations wider. These two points assume great practical importance.

Another portion of the vanadium enormously strengthens the pearlite alloy, raising its elastic limit especially, and in addition promotes the cohesion of this alloy with ferrite. From these facts the explanation is readily seen as to why the strengthening effect of vanadium increases rapidly as the proportion of elements other than iron (such as carbon, nickel, chromium, manganese, etc.) rises to the limits allowable in engineering steels, which limits are fixed by other considerations which it is needless for me to enter into.

The following table illustrates the effects of vanadium in increasing the static strength of material:

Rolled Bars Untreated.	Elastic limit. Lbs. per sq. in.	Ultimate tensile stress. Lbs. per sq. in.	Elongation on 2 in. Per cent.	Reduction of area. Per cent.
Crucible Steels 0.20% Carbon:				
Plain Carbon-manganese.....	35,840	60,480	35	60.0
" + 0.5 per cent. chromium.....	51,296	76,160	33	60.6
" + 1.0 " ".....	56,000	85,568	30	57.3
" + 0.1 " vanadium.....	63,840	77,052	31	60.0
" + 0.15 " ".....	68,096	81,760	26	59.0
" + 0.25 " ".....	76,384	88,032	24	59.0
" + 1.0 " chromium + vanadium.....	81,088	108,864	24	56.6
" + 0.15 " chromium + vanadium.....	90,496	135,296	18.5	46.3
Open-hearth Steels 0.3% Carbon:				
Plain carbon-manganese.....	39,648	72,128	34	52.6
" + 1.0 per cent. Chromium.....	77,056	116,480	25	55.5
Crucible Steels 0.2% Carbon:				
+ 5% Nickel Steel.....	58,240	94,080	24	50.0
+ .25% vanadium.....	116,700	129,700	20.5	52.4

It may be said what is now generally recognized, that it is not lack of successful resistance of steel to one steadily applied strain which causes that steel to fail in the huge majority of instances, but rather its steady deterioration under the demoralizing effect of strains which, though in themselves very much

less severe, are continually repeated. A true factor of safety can only be arrived at by consideration of both the useful strength of the material (which useful strength, be it noted, is represented by the elastic limit and not by the ultimate stress required to break the metal) and its ability to withstand deterioration under repeated stresses and strains, both statically and dynamically applied. The absolute pre-eminence of vanadium steels in resisting such deterioration has been thoroughly established as the result of many thousands of dynamic tests made under all kinds of conditions.

Table No. 1 also illustrates the high combinations of static and dynamic excellence obtainable by oil-tempering the vanadium compound steels, while table No. 2 illustrates the great effect of vanadium on the improvement in strength due to oil tempering.

Table No. 3 enumerates some of the leading types of vanadium steel in general use and the applications to which these various steels are put. Type "A" and its milder variants, "B" and "C," have already been sufficiently spoken of.

The tempered type "D" steel is exceptionally suited for the manufacture of springs, as will be seen from the diagram (Fig. 1) illustrating the results of comparative tests of vanadium and carbon steel railway springs made by an independent examiner. These springs were 16-leaf locomotive springs made to a standard design. It may be said that a new "carbon steel" spring was tested, but that the vanadium steel spring tested had already been subjected to gross distortion; its great superiority, however, even under the circumstances, is amply demonstrated. Variants of this class of steel in a softer condition than that pertaining to a spring are particularly applicable to the preparation of rails, tires, solid wheels, etc., a metal of great strength, high resistance to shock, impact, repeated stresses and of a structure highly resistant to abrasion being attainable by direct means.

Time will not permit me to go with any semblance of detail into the subject of case-hardening. As the object of case-hardening is to obtain an article which, although it has an exceedingly hard surface, at the same time shall have a tough resistant core, it naturally is inadmissible to case-harden any steel which in itself "takes a temper" as the result of quenching. The great increase in strength due to quenching mild vanadium steel is il-

TABLE NO. 1.

Test.	Vanadium				
	Carbon "Axle" Steel.	Nickel "Axle" Steel.	Vanadium Steel, Type A.	Vanadium Crank Steel, Type A.	Gear Steel, Mesh, Type A.
Yield point, lbs. per sq. in.....	41,330	49,270	63,570	110,100	224,000
Ultimate stress, tensile strength in lbs. per sq. in.....	65,840	87,360	96,080	127,800	232,750
Ratio.....	62%	56%	66%	87%	96%
Elongation on 2 in.....	42%	34%	33%	20%	11%
Contraction of area.....	61%	58%	61%	58%	39%
Torsional twists.....	2.6	3.2	4.2	2.5	1.8
Alternating bends.....	10	12	18	10	6
Pendulum impact, foot pounds.....	12.3	14	16.5	12	6
Alternating impact, No. of stresses failing weight on notched bar, number of blows.....	960	800	2,700	1,850	800
Rectar vibrations, number of revolutions.....	25	35	69	76	.....
	6,200	10,000	67,500	.....	.....

TABLE NO. 2.

Crucible Steel.	Elastic Limit Lbs. Per Sq. In.	Ult. Tens. Strength Lbs. Per Sq. In.	Elongation % on 2 in.	Reduction of Area %
*Carbon Steel as Rolled.....	61,100	82,700	24	49.7
" Oil Tempered.....	71,460	91,800	17	52.3
Chrome Vanadium Steel as Rolled.....	90,500	135,300	18.5	46.3
" Oil Temp'd.....	141,000	147,000	17	57.0
Nickel Vanadium Steel as Rolled.....	116,700	129,700	20.5	52.4
" Oil Tempered.....	179,900	185,300	14.5	50.5

\* N. B.—The Carbon Steel was made in the crucible from a Swedish "base" and therefore shows higher results than would be expected in ordinary open hearth practice.

TABLE NO. 4.

	Vanadium Low Carbon Steel as Rolled.	The Same Steel Quenched in Water from 850° C.
Elastic limit (lbs per sq. in.).....	44,790	78,390
Ultimate tensile strength (lbs. per sq. in.).....	55,990	100,800
Elongation on 2 in.....	45%	22%
Reduction of area.....	69%	60%

TABLE NO. 3.

Type.	Composition.	Applications.	Heat Treatment.
A 1....	Carbon ... .25—.30% Manganese .4 —.5 % Chromium. .1% Vanadium .16—.18%	Light axles, connecting rods, side and main rods, driving axles, piston rods.	Anneal at 800° C. for one to two hours, cool in air or ashes.
A 2....	Carbon ... .25—.30% Manganese .4 —.5 % Chromium. .1% Vanadium .16—.18%	Crank shafts, transmission parts, crank pins.	Quench from 900° C. in lard or fish oil and anneal at 550° C. for ½ to 2 hours in air.
A 3....	Carbon ... .25—.30% Manganese .4 —.5 % Chromium. .1% Vanadium .16—.18%	Gears in constant mesh.	Quench from 950° C. in lard oil and let down at 360° C. for ¼ to ½ hours preferably in lead bath. Cool in air.
B .....	Carbon .... .2 % Manganese .3—.4 % Chromium . .5 % Vanadium . .12%	Axle work, hammer rods and where torsion is of great moment, bolt steel.	Normal.
C .....	Carbon ..... .2 % Manganese .... .4 % Chromium .... .8 % Vanadium ..... .16%	Intermediate steel, useful for car axles, holding bolts, etc.	Normal.
D 1....	Carbon ... .45—.55% Manganese .8 —1.0% Chromium 1.25% Vanadium .18%	Solid wheels for railways, gun barrels, crank pins.	Anneal at 800° C. for one hour, cool slowly, taking great care not to chill or to pass from 800° to 600° too quick.
D 2....	Carbon ... .45—.55% Manganese .8 —1.0% Chromium 1.25% Vanadium .18%	Springs for automobile, carriage and locomotive work.	Quench in oil from 900° C. and draw back at 400° to 450° C. in lead bath preferred. Cool in air.
E .....	Carbon ... .12—.15% Manganese . .2 % Chromium . .3 % Vanadium .12%	Case hardening steel for all engine and machine parts.	Regular case hardening process.

REMARKS.—All steels to be as pure as possible from sulphur and phosphorus. Sulphur may go to .035% without detriment. With phosphorus at .02% silicon may be .15% in D and .10% in A, B, C. With phosphorus at .03% silicon should not exceed .05% to .06% in A, B, C, or .1% in D.

illustrated in table No. 4 and its power of toughening carbides has been dealt with.

Taking advantage of these points, the outside carburizing and the quenching of special mild vanadium steel leads to results which are unapproachable when combinations of resistance to wear, strength, and toughness are considered.

#### A SENSIBLE TENDER STEP.

The Canadian Pacific Railway has recently adopted as standard the tender step, shown in the illustrations. The two-inch holes in the step allow the snow and ice to fall through, while



TENDER STEP—CANADIAN PACIFIC RAILWAY.

the small projections or lugs afford a secure foothold. The high flanges prevent the feet from slipping over the ends. Those who have occasion to climb aboard engines or tenders, especially during winter weather, or when the light is poor, will readily appreciate the good features of this design.

#### TO PROMOTE THE RESUMPTION OF NORMAL BUSINESS CONDITIONS.

At a meeting of the Board of Directors of The Merchants' Association of New York, Thursday, November 21st, the following resolution was unanimously adopted:

*Resolved*, That the Board of Directors of the Merchants' Association of New York submits the following views and recommendations concerning the present financial situation for the consideration of its members and others, hoping thereby to promote the common welfare and to accelerate the resumption of business under normal conditions, viz.:

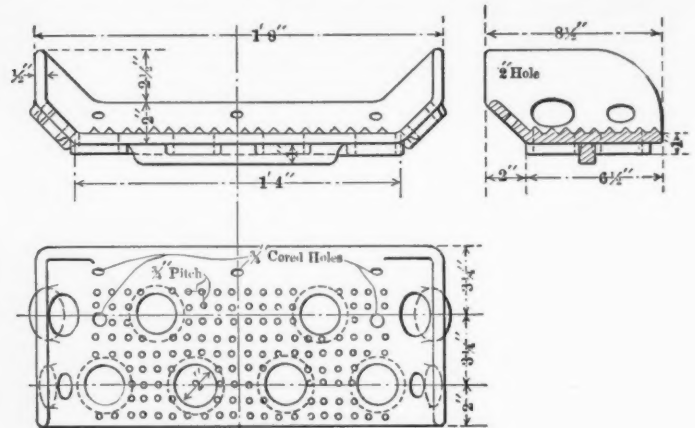
1. The chief present difficulty is stringency caused by the hoarding of the circulating medium of the country.
2. All financial leaders and practically all banking institutions have united in urging the people to cease this hoarding and to restore the circulating medium to its customary channels and uses.
3. The banks, above all others, should set the example thus implied; some of them have done so, but many are alleged to be doing just what they condemn in others. For example, some are known to be holding cash reserves ranging from two to five times the normal ratio.
4. The purpose of a surplus or cash reserve is for use in time of need; to withhold it from such use is to defeat its true purpose, tends directly to intensify the condition which it should alleviate, and is a selfish effort to protect the individual bank at the expense and to the injury of the banks collectively.
5. Checks payable "Through Clearing House only" are useful for local settlements, but do not pay non-local debts. The business of all large manufacturing and mercantile concerns is chiefly non-local, and cannot go on if local funds are everywhere tied up. Interstate exchange is essential to the

conduct of interstate business, and this constitutes the greater part of our domestic exchanges. Provision for the settlement of local indebtedness is helpful, but provision for the settlement of non-local indebtedness is essential, and, therefore, still more helpful.

6. If all concerned and in all parts of the country will recognize and act upon these self-evident conditions which underlie our commercial and financial system; if each corporation, bank and individual, instead of hoarding currency, will pay it out or deposit it in bank, and, instead of deferring settlements, will pay every account as promptly as possible, then, as predicted by Secretary Cortelyou in his notable address to The Merchants' Association on the 14th inst., there will be "within twenty-four hours an almost complete resumption of business operations," and the present stringency will become a thing of the past.

7. Our crops are large, our mining, manufacturing and commercial facilities greater than ever before, our transportation facilities overtaxed to handle the business which is offered to them, our population is larger and its consuming power greater than at any previous period, and no undue accumulation of merchandise is known to exist.

8. No comparison can fairly be made between the sound basic conditions prevailing to-day and the unsound conditions which obtained in 1893. We are now firmly on a gold basis, with an overflowing National Treasury.



DETAILS OF TENDER STEP.

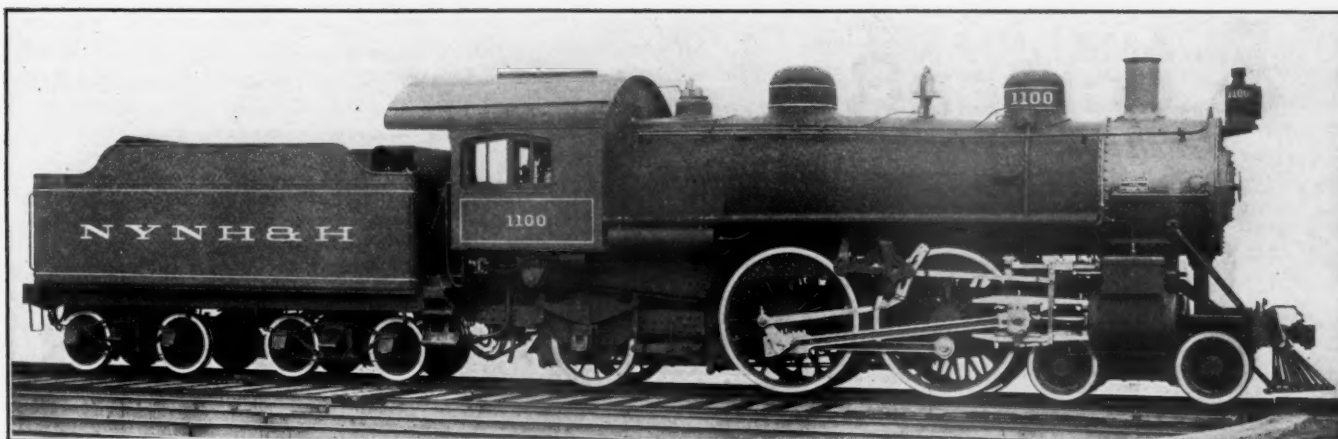
The recent trouble has been attributed to an "excess of prosperity." Wise legislation by Congress to make our currency elastic enough readily to respond to business conditions may confidently be looked for this winter. With all of these favoring conditions the onward march of our national prosperity will surely be resumed without delay.

9. Let every good citizen, solicitous of the welfare of our country, do his best to accelerate the return to normal conditions by continuing his business operations without alarm and by assisting in the present movement to bring all the money now lying idle into active circulation, and all will be well.

#### INCREASE OF WEIGHTS ON LOCOMOTIVE DRIVERS.

Mr. H. W. Willie, assistant superintendent of the Baldwin Locomotive Works, presented a discussion on the steel rail specifications at the last annual meeting of the American Society for Testing Materials, which included some very interesting figures concerning the increase in total weight and weight on drivers of locomotives built at the Baldwin Locomotive Works for a period of 22 years. This data was presented in the form of curves for different classes of locomotives and showed that the increase in total weight, weight on drivers, and average weight per axle for the American type locomotive had increased steadily from 1885 to 1905, when it reached a maximum, and had since fallen off. All other classes are still increasing, although the percentage of increase is falling somewhat. The maximum average total weight for the American type was shown as 132,000 lbs.; average weight on drivers, 90,000 lbs.; and weight per driving axle 45,000 lbs. Similar data for 10-wheel locomotives shows that they have increased from 87,000 to 161,000 lbs. total and from 65,000 to 122,000 lbs. weight on drivers and from 21,900 to 40,600 lbs. per driving axle. Mogul or 2-6-0 type increased from 85,000 to 154,000 lbs. total, from 70,000 to 133,000 lbs. weight on drivers and from 23,500 to 44,000 lbs. weight per driving axle. Consolidation locomotives increased from 112,000 to 200,000 lbs. total, from 97,000 to 179,000 lbs. weight on drivers and from 23,250 to 44,750 lbs. weight per driving axle.

The maximum axle load in 1885 was 24,000 lbs. and in 1907 it was 53,900 lbs. The average axle weights of all types of locomotives has increased 112 per cent. in the 22 years.



ATLANTIC TYPE LOCOMOTIVE WITH WALSCHAERT VALVE GEAR—NEW YORK, NEW HAVEN &amp; HARTFORD RAILROAD.

## ATLANTIC TYPE LOCOMOTIVES.

NEW YORK, NEW HAVEN &amp; HARTFORD RAILROAD.

On page 429 of the November issue of this journal appeared an illustrated description of a Pacific type locomotive, 30 of which have recently been put into service on the New York, New Haven & Hartford Railroad. In that article will be found a brief outline of the service for which those locomotives were designed, in which it was erroneously stated that the trains hauled by those engines were operated on a schedule of five hours between New York and Boston, a distance of 232 miles. The Pacific type locomotives are actually intended for service on the six-hour trains, weighing 550 tons or more, and for the five-hour trains, of which there are four each way, each day, an Atlantic type locomotive has been designed. The first order of twelve of this type is now being delivered by the American Locomotive Company.

The demand for these locomotives originated from the same causes as mentioned in connection with the Pacific type, that is, the lack of steam making capacity of the ten-wheel type, which has heretofore been used in this service, whenever it was necessary to increase the train above its normal weight.

These locomotives are duplicates of the Pacific type in many details and differ from that design, in addition to the wheel arrangement, largely in the following particulars: An extended wagon top type of boiler is used instead of the straight type; 2 in. flues are installed in place of 2¼; the flues are but 16 ft. 10 in. long in comparison with 20 ft. 6 in.; the cylinders are 21 x 26 in. instead of 22 x 28 in. and the drivers have a diameter of 79 in. in place of 73 in.

These changes are so inter-related as to give very nearly the same ratios as were obtained on the larger design. The reduction in size of cylinders and increase in diameter of drivers reduces the tractive effort to 24,700 lbs. which gives the same ratio of adhesion as is obtained with 31,600 lbs. tractive effort on the Pacific type. The cutting off of 3 ft. 8 in. in flue length, in spite of the increased number of flues, reduces the total heating surface by nearly 700 sq. ft., although the grate area remains the same. This has had the effect of slightly altering the ratios concerned with the heating surface and increases the B. D. factor from 587 to 597. The amount of heating surface per cubic foot of cylinder volume is reduced but slightly. In comparison with other locomotives of the same type it will be found that the ratios of the New Haven design approach very closely the average of the best designs in recent years.

The general dimensions will be found in the following table:

## GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	24,700 lbs.
Weight in working order	200,000 lbs.
Weight on drivers	105,500 lbs.
Weight of engine and tender in working order	334,000 lbs.
Wheel base, driving	7 ft. 3 in.
Wheel base, total	28 ft. 2 in.

Wheel base, engine and tender	56 ft. 1 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.26
Total weight ÷ tractive effort	8.10
Tractive effort × diam. drivers ÷ heating surface	597.00
Total heating surface ÷ grate area	60.80
Firebox heating surface ÷ total heating surface, per cent.	6.50
Weight on drivers ÷ total heating surface	32.40
Total weight ÷ total heating surface	61.30
Volume both cylinders, cu. ft.	10.40
Total heating surface ÷ vol. cylinders	314.00
Grate area ÷ vol. cylinders	5.15
CYLINDERS.	
Kind	Simple
Diameter and stroke	21 × 26 in.
VALVES.	
Kind	Bal. Slide
Greatest travel	6¾ in.
Outside lap	1 3/16 in.
Inside clearance	¼ in.
Lead, constant	5/16 in.
WHEELS.	
Driving, diameter over tires	79 in.
Driving, thickness of tires	3½ in.
Driving journals	10 × 12 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6 × 12 in.
Trailing truck wheels, diameter	51 in.
Trailing truck, journals	8 × 14 in.
BOILER.	
Style	Ex. Wagon Top
Working pressure	200 lbs.
Outside diameter of first ring	67¼ in.
Firebox, length and width	108½ × 71¼ in.
Firebox plates, thickness	¾ and ½ in.
Firebox, water space	F. 5, S. and B. 4 in.
Tubes, number and outside diameter	347—2 in.
Tubes, length	16 ft. 10 in.
Heating surface, tubes	3,041.3 sq. ft.
Heating surface, firebox	213.2 sq. ft.
Heating surface, total	3,254.5 sq. ft.
Grate area	53.5 sq. ft.
Smokestack, diameter	16 in.
Smokestack, height above rail	14 ft. 9½ in.
TENDER.	
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	6,000 gals.
Coal capacity	14 tons

## THE NATURE OF TRUE BOILER EFFICIENCY.

A paper by Messrs. W. T. Ray and Henry Kreisinger presented before the Western Society of Engineers, September 18, reviews the boiler tests which have recently been conducted by the Steam Engineering Division of the U. S. Geological Survey for the purpose of determining the laws governing the rate of heat absorption by boilers. The deductions drawn from these experiments as presented in the paper indicate that:

1. After the velocity of gas parallel to the heating surface has reached a certain value, which varies with the size of tubes and degree of temperature, the rate of heat absorption is almost proportional to the velocity.

2. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

3. Increasing the diameter of flues decreases the efficiency of their absorbent power; increasing the length of flues beyond a certain limit, depending upon their size, increases their efficiency very little.

4. Most of the resistance to the passage of air through the flues is at the entrance into the tubes. The length of the flues increases the resistance but little.

(Established 1832).

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**Advertisements.**—Nothing will be inserted in this journal for pay, EXCEPT IN THE ADVERTISING PAGES. The reading pages will contain only such matter as we consider of interest to our readers.

**Contributions.**—Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.

**To Subscribers.**—The AMERICAN ENGINEER AND RAILROAD JOURNAL is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.

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## THE ANNUAL INDEX.

We find that such a large proportion of our readers are having their numbers of this journal bound for reference that we have taken special pains this year to make the annual index as complete as possible, in order to facilitate reference to articles on any subject. The very complete sub-index of the New York Central Lines apprentice system articles will be appreciated by those who are specially interested in the apprentice question.

One is often quite disappointed after hunting up an article to find that it is a small note instead of an article of importance. In addition to our usual distinction between illustrated and non-illustrated articles we have therefore made a distinction between the non-illustrated articles of considerable length, the shorter ones, or notes, as we are accustomed to call them, the editorial comments and the communications. This, however, should not be taken to indicate that the shorter articles or notes are not of value, for quite often they contain a summary of the most important results from important investigations or discussions. We trust that our readers will find the improvements which we have made of convenience and practical value.

## STEEL PASSENGER CAR DESIGN.

On page 210 of the June issue of this journal appeared the first and introductory article of a series by Charles E. Barba and Marvin Singer on the subject of steel passenger car equipment. Owing to causes beyond our, or the authors', control, the series was interrupted and the second article appears in this issue.

As far as we know this is the first elaborate treatment of this subject that has ever appeared. The authors are men who have had exceptional opportunities for becoming thoroughly conversant with steel car design, for both passenger and freight service and are treating their subject in an eminently practical manner. The present article introduces the subject of the underframe and thoroughly discusses all of its more important features. This will be followed by a very interesting graphical analysis of underframe stresses, which in turn will be followed by a most thorough and practical analytical treatment of the different types of underframe, giving the designer a practical illustration of the exact method of handling the subject. Future articles in the series will consider the design of the superstructure, interior fittings, exterior finish, lighting, heating, ventilation, etc., and will in all probability run throughout the coming year. We count ourselves exceptionally fortunate in being able to present so complete a treatment of this increasingly important subject.

## SPIRAL TUBES IN SUPERHEATERS.

One of the characteristics of highly superheated steam is its poor conductivity of heat. This is an excellent feature after the steam has reached the cylinder, as it greatly assists in preventing condensation, the greatest loss of cylinder efficiency with saturated steam, but it works quite the other way in the superheater. There, in the smoke tube type, we have the steam flowing at a high velocity through a large number of small tubes, in each of which there is a film of steam in contact with the metal, which is highly superheated and acts as an insulation tending to prevent the transfer of heat to the center of the pipe. This necessitates holding the steam in the region of high temperature for a comparatively long time and hence the use of a large amount of superheating surface, in order to deliver highly superheated steam. The resulting disadvantages are not only the sacrifice of considerable boiler heating surface but also an increase in the number of joints and parts in the superheater. A design has recently been brought out in this country which takes note of this feature and by flattening the tubes, thus sending the steam through in a wide, thin jet, expects to increase the efficiency of the apparatus.

It would seem as if this difficulty could be largely overcome, and that a superheater could be designed which would deliver steam at a high temperature with considerably less total heating surface, by the use of either the spiral or Servé tubes, provided

that tubes of those types can be obtained to withstand the internal pressure. The former, by reason of the circular motion given the steam in each tube, would tend, by centrifugal action, to throw the steam at a lower temperature, which is necessarily heavier, toward the outside of the tube and thus continually break up the film of insulation above mentioned. The Servé tube would accomplish a similar result by conducting the heat to the center of the steam by means of the metal wings on the interior.

### VANADIUM STEEL.

Tests and practical experience have shown that the addition of a very small amount of vanadium to either carbon or alloy steel has a wonderful effect in improving the characteristics of the product. This effect is possibly most noticeable under conditions of alternate and repeated stresses, which, it is well known, will finally rupture the best steel, even though they singly be considerably below the elastic limit of the material. This condition, known as "fatigue," is amply allowed for in the design of axles and other parts subjected to alternate stresses, and in many cases results in very undesirable large sections because of the anxiety of the designer to surely be on the safe side. Even under these conditions, with apparently ample allowances, axles, main rods, etc., have been known to fail from this cause and the opportunity of obtaining a material offering large improvement in this respect will no doubt be rapidly taken advantage of.

Frame breakages are a source of constant trouble on practically all roads and even with careful records, covering long periods of time, it is almost impossible to locate the causes. As a matter of fact we know very little about the stresses in a locomotive frame and our designers are often compelled to go at it blindly, having only past experience, usually with lighter and differently arranged power, to guide them. The indications are that vanadium steel can be used to great advantage for this purpose. Its cleansing action will permit greater reliance to be placed upon steel castings, which, even if it did not result in other benefits, would greatly recommend it for railroad use. Having, however, as it does, a largely increased ultimate tensile strength, a higher ratio of elastic limit and a greatly improved dynamic resistance, makes it a material which our locomotive and car designers cannot afford to neglect.

In fact we believe that this latest development in the steel makers' art will prove to be of so great importance that we devote considerable space in this issue to an abstract of a paper by Mr. J. Kent Smith, which clearly explains what the material is and what it will do.

### FEED WATER HEATERS.

The possibilities of a feed water heater look very attractive and it is altogether probable that eventually a successful device of this kind will be found on many of our locomotives. So far in this country, however, the efforts in this line have been largely confined to spasmodic attempts to heat the water in the tank by means of the air pump exhaust before it reaches the injector. Some saving can no doubt be made in this way, but the full benefits of hot feed water require much more than this. It should enter the boiler at practically the temperature of the water already there, or 388 degrees at 200 lbs. pressure, and thus require but comparatively little additional heat to convert it into steam and also cause no temperature strains in the boiler structure. That is the ideal condition and to attain it would probably introduce a more or less clumsy arrangement in the front end or a series of heaters such have been fitted by Mr. Trevithick to a locomotive on his road, shown in our November issue. Such an arrangement would not be looked upon with favor by American motive power officials and it is probable that the successful device will not attain ideal conditions. There is a broad gap, however, between tank heating and the ideal in which there is room for considerable study and experimenting. It should be remembered that a device which is going to require any great amount of attention at terminals, even if it does get over the road, will not be popular.

The trouble which will be caused by the chocking of a heater delivering water at a high temperature, particularly where water with much scale forming salts in solution is used, is the most serious feature to be considered. This makes it almost imperative to give it terminal attention every few trips. Probably the most practical way out of that difficulty would be to arrange the construction somewhat along the lines used in evaporators on ocean steamships where the nest of scaled tubes can be easily and quickly removed and replaced with a clean set.

### RAILROAD CLUB PAPERS

A group of mechanical department officials, while recently talking of railroad clubs, practically all admitted that papers that they had prepared for one or another of the clubs had been the means, at least to some extent, of considerably extending their acquaintance and getting them better positions. A college professor, from whom many of the younger men on our railroads have received instruction and inspiration, used to speak to his students somewhat in this manner, as they were about to be graduated. "Remember that it is just as essential for you to advertise yourself as it is for the manufacturer to advertise his wares. You can't very well do it in the advertising pages of the technical papers unless you are a consulting engineer. You can, however, advertise yourself and make your ability known to much better advantage by participating in discussions at railroad club meetings, by preparing papers to be read at such meetings, or by writing for the technical press. Don't attempt to take such action unless you have something of real value to impart."

A young man, who was regarded by his superiors in the mechanical department of one of our railroads as being of more or less promise, was asked to prepare a paper for the local railway club. He selected a subject which would have yielded much if carefully and patiently investigated, and which, if handled in this manner, would have undoubtedly attracted widespread attention. The records of the road were at his command, and higher officials and his associates would have been glad to have given him any assistance in their power. The paper, when presented, was a disappointment, for it treated the subject in a superficial manner and did not bring out any really valuable information, or make any suggestions as to improvements in general practice. It really hurt the young man. He never got any farther with the company he was with, although it had a special need for good men in positions to which he should have been eligible for promotion. Although this happened a long time ago the officials of the road in question still remember the incident and speak of it as an indication of the true worth of the man.

Another young man was notified one day that the railroad club was in sore straits, since a paper which had been promised for the next meeting, only two weeks away, would not be forthcoming. In spite of his youth and limited experience he was asked to help out by preparing a paper. It was at a time when his work and outside affairs were in such shape that he would have been justified in declining, but he felt that he had been honored by the request and determined to do his best to "make good." No midnight oil was spared and it is even said that his wife helped him in getting the article into readable shape. The paper was a success and abstracts of it appeared in practically all of the leading railroad technical papers. Attention was directed to the young man and it was not long before he was promoted to a more important position, and he found afterwards that his railroad club paper was to a large extent responsible for it.

It is not at all uncommon to find the executive committee, or secretary, of a railroad club more or less discouraged because of the difficulty of getting good papers. One would reasonably expect that the trouble would rather be to keep from getting too many, but this is not so. The technical editor is usually pictured as having his desk heaped high with first-class contributed matter, but this also is not true, in fact it is a most serious task to keep a steady supply of the right kind of material coming in. For instance, it has been the policy of this journal for many

years to try and bring out the younger men and encourage them to become contributors, but where 20 have been urged to do this not more than one or two ever respond. Three years ago the editor made a list of a dozen acquaintances in railroad mechanical departments, all young men of good education and more or less promise. After two years of systematically prodding them up, even going so far as to suggest subjects which certain ones were well qualified to follow up, the result was just one good article—and that from the busiest man in the lot, and he is certainly making good at the present time. The others are all doing well, but most of them seem to have fallen into a rut and appear to be "hiding their light under a bushel."

You say that the average mechanical department employee is overworked and has no business writing for clubs or technical papers, even if it is on his own time. Just take some subject with which you feel that you are familiar and sit down and try to prepare an article for publication and you will possibly find that there are a good many things in it that will bear still further investigation, and when the article is completed you will know considerably more about your subject than you did when you started. At any rate work of this kind does not apparently interfere with a man doing his full duty to the railroad company and making a success of himself, as you will discover if you will glance over the names of some of the contributors in the older files of this journal.

It is a mistake to prepare an article or to take part in a discussion unless you can impart something that will really help or inspire your readers or hearers. Say what you have to say in a few, clear cut, well chosen words. No matter how familiar you are with the subject it is a mistake to try to take part in a club discussion without some previous preparation unless you have had more or less experience in speaking extemporaneously, and even then things are often said which do not convey the correct impression and others are overlooked which should have been said.

**POWER CONSUMED BY ELECTRIC TRAIN LIGHTING.**—The steam consumption with an engine driven electric lighting set in the baggage car, while the plant is in operation, is from 700 to 900 lbs. for eight-car trains, or approximately 100 lbs. per hour per car. The set operates from 8 to 10 hours a day and it may be taken at an average figure that about 900 lbs. of steam is consumed per day per car. With an axle driven set the average power absorbed from the axle throughout the run is between 2 and  $3\frac{1}{2}$  horse power per car, depending upon the character of the car and the system used. For extended lines overland this continues for twenty-four hours of each day and consequently 48 to 60 horse power hours are consumed. Assuming 30 lbs. of steam per hour consumed by the locomotive per horse power at the car axle, the axle driving set will consume from 1,500 to 1,800 lbs. of steam every twenty-four hours. When, however, the run comprises only the time of a single night or less, instead of extending over twenty-four hours, the advantage very rapidly turns toward the axle driven equipment.—*Dugald C. Jackson, before the Western Society of Engineers.*

**THE PROPERTIES OF MALLEABLE CAST IRON.**—Malleable cast iron consists almost entirely of ferrite and temper carbon. It has a tensile strength of from 40,000 to 60,000 lbs. per square inch, with an elongation of from  $2\frac{1}{2}$  to 5 per cent., which in special cases may go as high as 8 per cent., and a reduction of area of  $2\frac{1}{2}$  to 8 per cent., and may go as high as 12 per cent. A one-inch bar on supports 12 in. apart should bear a load at the center of at least 3,500 lbs. and be deflected at least  $\frac{1}{2}$  in. before breaking. Thin sections should be capable of being flattened out under a hammer and bent double without cracking.—*Bradley Stroughton in "School of Mines Quarterly."*

**HIGH SPEED BOAT.**—The British torpedo boat destroyer, "Mothawk," according to press dispatches, maintained a speed of  $34\frac{1}{4}$  knots, or nearly 40 miles, per hour for six hours during its speed trials on November 15.

## ELECTRIFICATION OF THE ROCHESTER DIVISION OF THE ERIE RAILROAD\*

The first installation of the single phase alternating current system of electric motive power upon a steam railroad, to go into commercial operation, was a portion of the Rochester Division of the Erie Railroad, which was opened on the 18th of June. This, in addition to being the first to operate single phase cars on a steam railroad, was also the first to use 11,000 volts working pressure commercially on a trolley in this country, having preceded the New Haven System in both of these respects by a few weeks. It is also the first instance of a heavy electric traction system receiving power from a 60,000 volt transmission line. All of the construction of this system, except that of the 60,000 volt transmission line and the car bodies and trucks, was designed, executed and placed in operating condition by Westinghouse, Church, Kerr & Co., engineers.

The section of track electrically equipped is 34 miles long, extending from Rochester, N. Y., over the main line of the Rochester Division, to Avon, a distance of about 19 miles, thence 15 miles over the Mt. Morris branch. The railroad is entirely single track with sidings at way stations, averaging three or four miles apart. The grades are light and the curvature for the most part quite easy.

The line was originally laid with 68 lb. rails, but was re-laid with 80 lb. rails just prior to the electrification. A single No. 2/0 protected rail bond is applied to each rail joint under the plate. Because of the high tension system comparatively light rail bonding is possible.

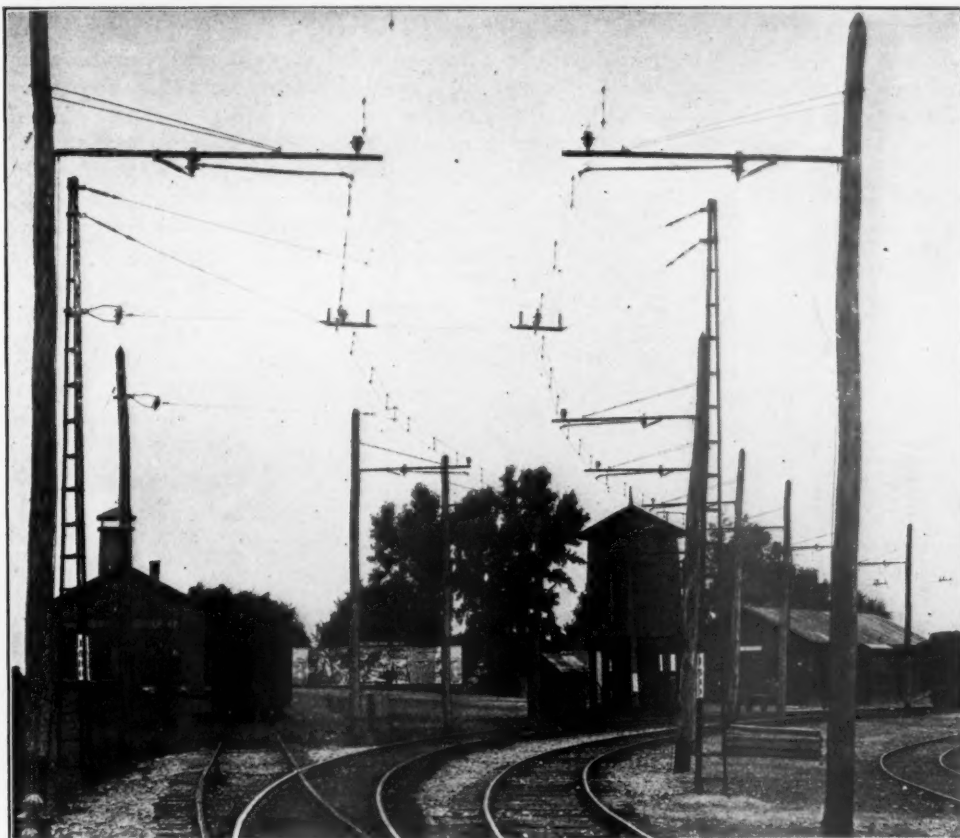
The electric service is devoted wholly to passenger traffic, which is of the local interurban type. The freight service is handled exclusively by steam locomotives, as heretofore, as are also the through passenger trains. The steam service between Rochester and Mt. Morris originally comprised three round trips daily. The electric service has permitted six round trips daily between Rochester and Mt. Morris and three more between Avon and Mt. Morris.

**Power Supply.**—The power is generated at Niagara Falls in the plant of the Ontario Power Company and is transmitted at 60,000 volts, three phase, over the lines of the Niagara, Lockport and Ontario Power Company, which crosses the Erie Railroad at Mortimer. From this point a branch line was constructed to Avon, being located upon the railroad right of way for nearly the whole distance. This line was carried upon poles of the A frame type, using two 40 ft. cypress poles set abreast of each other, and inclined so that their tops are framed together. The cross arm consists of two  $3\frac{1}{2}$ " x 6" x 8 ft. timbers, the insulators being located one on either end of the cross arm and at the apex of the poles, so that there is an equilateral spacing of 7 ft. between each of the three wires. Lightning protection was installed upon every fifth pole. The conductors are of No. 4, hard drawn, stranded copper cable, the standard length of span being 220 ft., which is shortened on curves where necessary.

**Substation.**—The single substation required for this installation is located at Avon, and together with the car inspection shed is adjacent to the roundhouse and division repair shop at this point. The walls of the building are of brick, resting on concrete foundation, the roof and floor being of reinforced concrete. The floors are supported upon steel beams, but the roof beams are of reinforced concrete. This building measures 39 ft. 8 in. by 44 ft. on the outside and is 29 ft. 10 in. high from the top of the foundation to the top of the parapets.

The basement of the building contains one of the transformer oil tanks and an oil pump. The main floor is divided into three rooms, the main transformer room being 43 x 17 ft. and extending the full height of the structure. The remaining space of the main floor is divided into a high tension room, through which the 60,000 volt circuit enters and an operating room where all of the 11,000 volt switching apparatus and measuring instruments are located. Over the operating room is a mezzanine

\* Based on an extensive descriptive article prepared and furnished by Mr. W. N. Smith, electric traction engineer, Westinghouse, Church, Kerr & Co.



VIEW SHOWING BRACKET AND SPAN CATENARY TROLLEY SUPPORTS—ERIE ELECTRIFICATION.

floor on which is located the 11,000 volt lightning arrestors, the 60,000 volt choke coils and the 60,000 volt series coils. The arrangement of these rooms and circuits is shown in one of the illustrations.

The transmission line terminates at the lightning arrestor yard in the rear of the substation, where an arrangement of 60,000 volt lightning arrestors is provided. From this the three high tension conductors enter the substation through glass discs held in 36 in. tile set in the upper portion of the rear wall of the substation. The circuit after entering the station passes through three circuit breakers mounted directly inside of the rear wall, thence over bare copper conductors to the three oil insulated choke coils on the mezzanine floor, thence to three oil insulated series transformers, from which connections are taken to the power measuring instruments in the operating room. The main connections finally terminate upon a set of copper bus bars in the transformer room, which are supported upon porcelain insulators mounted on wooden cross arms and placed at a convenient height directly over the transformers.

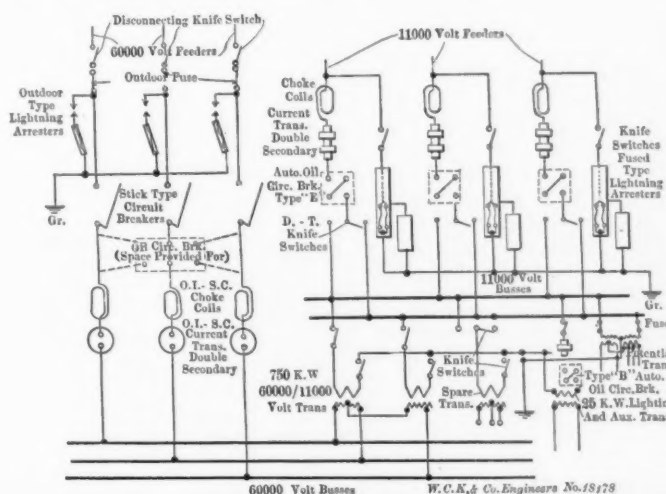
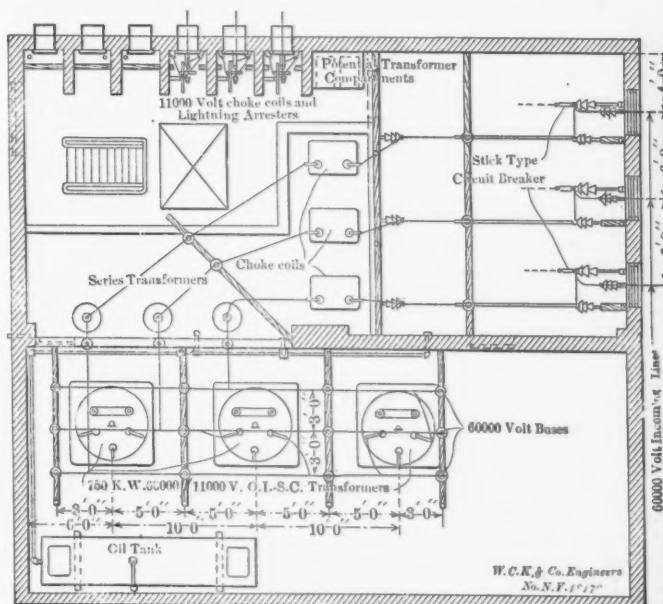


DIAGRAM OF CIRCUITS IN SUBSTATION.

This three phase current is rendered available for single phase distribution by means of three transformers of the Westinghouse oil insulated, water cooled type, each of 750 k. w. capacity. The high tension connections are such that in case one transformer fails while in service its connections can quickly be taken off the bus bars and put on the spare transformer, there being but two in regular use. The low tension windings are so connected that either 11,000 or 22,000 volts can be obtained. This has been so arranged on the possibility that, at some future time, it might be desirable to transmit current for a distance of 40 or 50 miles to another substation.

The current is transformed from three phase to two phase and the electrified line is divided into two sections, each of which uses one phase of the current. Either the T or V connection



PLAN OF SUBSTATION SHOWING LOCATION OF INSTRUMENTS.

can be used, the latter method, however, being employed at present. Arrangements have been made for conveniently removing a transformer or its coils, by the installation of a transfer track and a 10-ton hand hoist. Two cylindrical boiler iron tanks are provided, each being of slightly greater oil capacity than a single transformer. One of these is located in the basement directly under the transformer room, so that the oil can readily be drawn into it. The other is suspended from the concrete roof beams at the top of the room and acts as a reservoir for distributing oil back in the transformer. The oil is pumped from the lower to the upper tank by means of a steam pump, the steam supply being obtained from the adjacent roundhouse. By this arrangement it is a simple matter to draw the oil off from any transformer, if its insulating qualities are found to have depreciated, and a de-hydrating, filtering or purifying apparatus can readily be employed with the aid of a pump, and the supply returned again to storage.

The water circulation in the transformers is by gravity, the supply coming from the roundhouse water tank. There are three separate water cooling coils in each transformer case, each one controlled by its own valve, so that the amount of water can be varied as found necessary under the varying conditions of load.

The 11,000 volt bus bars run along the wall of the operating room, the circuit passing from them through oil circuit breakers, of which there are three, one being a spare, and thence to the mezzanine floor and through two low equivalent lightning arrestors and out through the substation wall.

Call bell circuits have been provided so connected that when a circuit breaker opens or the temperature of any transformer runs above normal, a bell is rung in the adjoining car inspection shed. The station itself does not require the constant presence of an attendant and it has been found that an average of one hour a day is all the attention needed.

**Catenary Trolley Construction.**—Nearly all of the line construction is of the bracket type, except over the railroad yards at several stations, where span construction is used. Chestnut poles, averaging 25 in. in circumference at the top and about 42 in. at the butt, and between 35 and 40 ft. long, are used. The poles are given about 12 in. rake and are tamped with cobble stones. The brackets consist of a 3 x 2½ in. T-iron 10 ft. long, the heel of which is fastened to the pole by a pair of bent straps, the other end being supported from the pole top by two ⅝ in. steel truss rods. These rods are attached about 27 in. back from the outer end of the bracket and run on either side of the pole to a clamp which grips the top instead of requiring the bolt or truss rod to pass through the wood. When necessary, extra long brackets are employed and an extra set of truss rods are provided. The insulator pins are of malleable iron and grip the flange of the T-bracket. On these are mounted insulators, 6⅞ in. diameter and 6 in. high, of the three petticoat type, being made in two parts. These insulators were specially designed for this installation.

The insulator pins are located ordinarily about 12 in. from the ends of the bracket, although their location can be varied to suit the alignment of the tracks.

The messenger wire is of "extra high strength" steel in seven strands and is 7/16 in. in diameter. The trolley wire is No. 3/0 B and S grooved copper.

The spans on straight line track are 120 ft. in length, and as much shorter as required on curves. The maximum deflection allowed from the center line of the track is 7 in. each way. The catenary hangers are of the drop forged type, the messenger clip and trolley clip being of the same type, but grooved differently to accommodate their respective wires. They are joined by a ⅝ in. hanger rod with right hand threads on each end, the longer rods being flattened in the middle to admit of bending, so as to conform to the divergence of the messenger and trolley wires near the ends of the span. The hangers are spaced about 10 ft. apart. Both the trolley and messenger ears are secured in position by jam nuts. The steady strain rods are of treated wood and are mounted on one side of the bracket, instead of directly underneath it, in order to give sufficient clearance for the pantograph trolley on curves. These rods are hinged to porcelain

strain insulators, which are clamped to one side of the bracket and can be shifted along it to follow up any change that may be required in the alignment of the trolley wire. Steady strains are used only on curves and turnouts and were not found necessary on tangent tracks.

Every trolley bracket is grounded to the rail so that an insulator failure will instantly throw off the power, and minimize the danger of setting the wooden poles on fire. The burning of a wooden pole would not itself necessarily cripple the electric service, but it would be quite likely to cause a dangerous obstruction to the passage of steam trains.

The span construction is, as nearly as possible, similar to the bracket construction, and uses the same type of pin and insulator. A piece of 3 x 2½ in. T-iron about 30 in. long is suspended from the span wire by adjustable hangers and the messenger wire rests upon the insulator the same as in the regular bracket construction. At several points special construction, which varies somewhat from the standard, was required.

A simple type of pull-off was devised for curves in span construction, which consists of a spool type insulator with a piece of piping cemented through the center, this pipe being slipped over the hanger spacing rod joining the messenger and trolley clips. This gives an insulating connection through which an ordinary pull over cable can be attached to both messenger and trolley wires wherever required and the division of the pull between the two wires can be easily adjusted to suit the conditions.

Only part of the line has been equipped with lightning arrestors. These are of the swinging fuse gap type of construction, made by the Westinghouse Electric & Mfg. Co. This type of arrestor consists of a gap, one side of which is connected directly to the trolley and the other to the ground. The latter connection being through a fuse enclosed in a tube, which, while the fuse is intact, is mounted in an inclined position, but when the fuse is blown, a latch is raised and allows the tube to swing to a vertical position. This difference in the position of the tube is easily seen from the ground and the blown fuse tube can be lifted off the suspending lugs by a pair of insulating tongs made for the purpose and the fuse renewed and replaced in a few moments.

The trolley line is divided into seven sections which are separated by trolley section insulators. These are of the overlapping type, made of impregnated wood of sufficient length to insure insulation at 11,000 volts. One of these breakers opposite the substation at Avon, differs from the others in that it is not of the overlapping type, since it is necessary at this point to absolutely separate the two halves of the trolley line in order to utilize the separate phases of the trolley current in each half.

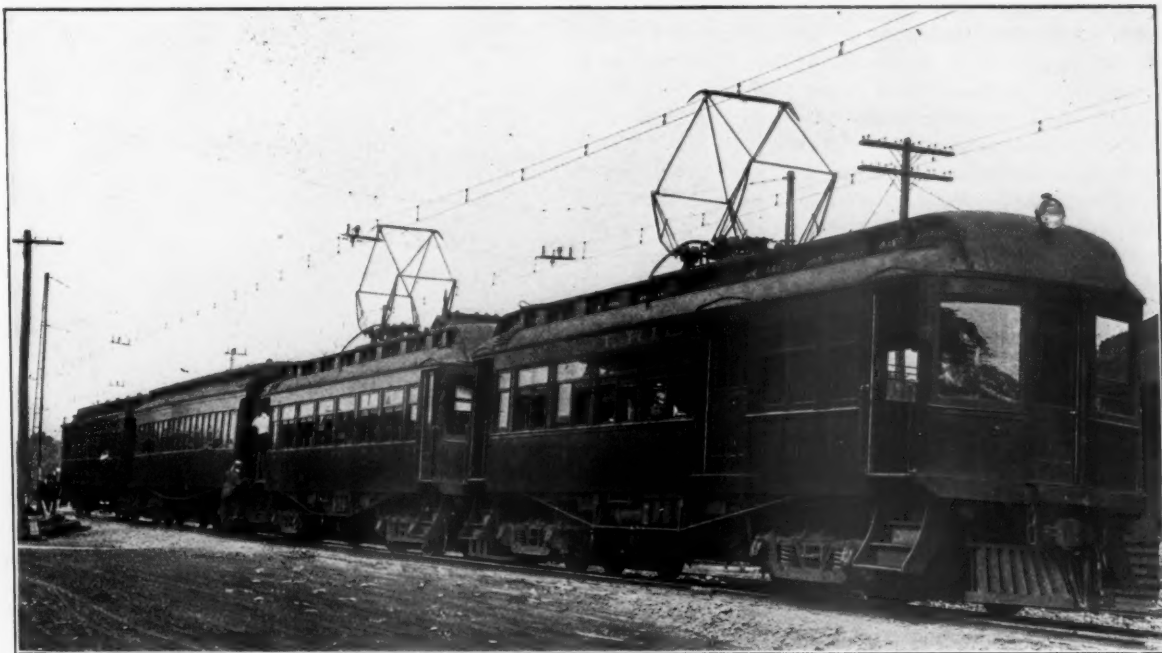
The only feeders necessary are those connecting the substation with the trolley on opposite sides of this section break. The principal object of cutting the trolley into additional sections is to facilitate the locating of line troubles.

**Electric Cars.**—At present there are but six cars equipped with electric apparatus in service on the electrified section. It is expected, however, that this number will be increased in the near future. These cars were built by the St. Louis Car Company and measure 51 ft. 4 in. over bumpers. Four of them are arranged in two passenger compartments and the other two have a baggage compartment in addition, with smaller seating compartments.

The construction is of composite steel and wood underframing with truss rods and a wooden superstructure. They are fitted with large vestibules and the end doors of the car are of the sliding type. The vestibule side doors are also of the sliding type and a double acting swing door is arranged in each vestibule so as to form a motorman's compartment, or if in the center or rear of the train, to be folded back to enclose the control apparatus and brake gear.

Each car is fitted with a 50 candle power headlight at each end on top of the hood, and each also has a gong, air whistle, and standard train air signal apparatus. The cars have standard M. C. B. couplings, air hose connections, etc., so as to couple with any of the standard steam rolling equipment.

The trucks are of the standard M. C. B. swing bolster type



SINGLE PHASE ELECTRIC TRAIN ON THE ERIE RAILROAD.

with inside hung brake beams. The wheel base is 6 ft. 8 in. and the axles are  $6\frac{1}{2}$  in. in diameter.

The electrical equipment of the cars consists of four Westinghouse single phase railway motors with a normal rating of 100 h.p. each driving the axles through gears, the gear ratio being 20.63. The suspension is of the nose type and solid gears are pressed upon the axles. The control system is of the Westinghouse electro-pneumatic type and includes three distinct circuits: the high potential, low potential and the control circuit.

The high potential circuit includes only the pantograph trolley, a line switch and the high potential coils in the transformer. The low potential circuit includes the switch group, the preventative coils, the reverser and the motors. The control circuit includes the master controller, one in each vestibule, the train

its base. When down, it is automatically locked and the latch of this lock can only be withdrawn by applying air pressure to another small cylinder, which will release it and allow the springs to raise the trolley. This trolley mechanism is so connected with the control circuit that any interruption in the supply of the high tension current or the opening of the line switch or main circuit breaker immediately causes the trolley to be lowered.

The line switch is operated by air pressure admitted by electrically operated valves and in case the supply of air has been exhausted, as when the car has stood for some time unused, a small automobile tire pump, placed underneath one of the car seats and connected into the trolley air piping system, is provided and enables the air operated control latch to be withdrawn, the trolley raised and power obtained that will start the air compressor. The line switch must be held in mechanically until the air compressor has furnished a pressure of 50 lbs., which is sufficient to properly actuate the control system.

The transformer is of 200 k. w. capacity and of the oil insulated type. It has three high potential and eight low potential taps, the latter running down as low as 110 volts, which pressure is used for heating, lighting and auxiliary purposes. The switch group consists of a set of air operated switches, controlled by magnet valves, all mounted in one frame. The switches are all provided with interlocks, which automatically give the connections in such a way that each switch of the group acts only when the current in the motors has reached a pre-determined value, thus making acceleration automatic. There are two reverser switches actuated by air pressure, one for each pair of motors. The current from the main motor circuit is led through the motor limit switch, which makes effective the functions of the interlocks and renders it impossible for the successive switches to be thrown in unless the limit switch is closed.

The master controller makes the proper connections by means of which the 15 volt control circuit actuates the valve magnets which control the action of the air operated main contactors in the switch group and the reversers. The control handle is normally held in a vertical central position by springs, unless it is moved to one of the running points by the motorman. When released it returns to a vertical position, shutting off the power and enabling the emergency application of the brakes by means of the brake relay valve alongside of it. There is a push button on each side of the master controller case. The one on the right side when pressed drops the trolley and opens the line switch. When the button on the left hand side is pushed the switch group is stepped up to the last or high speed notch and

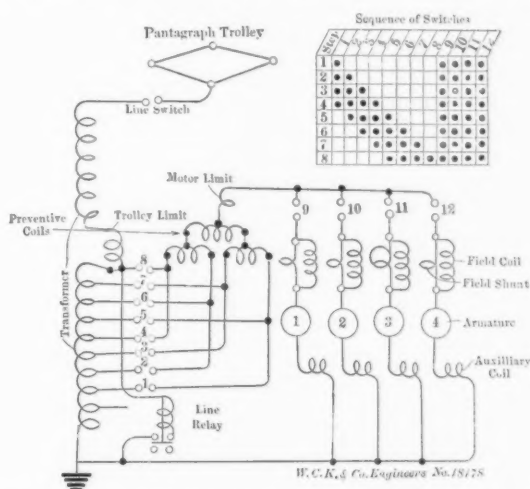


DIAGRAM OF HIGH AND LOW POTENTIAL CIRCUITS ON MOTOR CARS.

line wires, the valve magnets, and interlocks the storage battery supplying the current in this circuit and a motor generator set, which is used either to charge the batteries or to actuate the control system. The high potential circuit is at a pressure of 11,000 volts, the same as the trolley; the low potential circuit has various voltages, corresponding to different taps on the transformer and controlled by the switch group, and the control circuit is at a pressure of 15 volts.

The pantograph trolley mechanism is operated by a pair of springs and an air cylinder. The trolley is raised and held against the wire by means of the springs and is lowered by the application of air pressure in the cylinders which form part of

remains in that position until the handle of the controller has been returned to an off position.

In one vestibule is located a slate switch-board panel enclosed in an asbestos lined compartment, with steel doors, upon which are carried all of the switches and fuses for the control of the battery, motor generating set, lighting circuit, heaters and the main connection from the transformers and the auxiliaries.

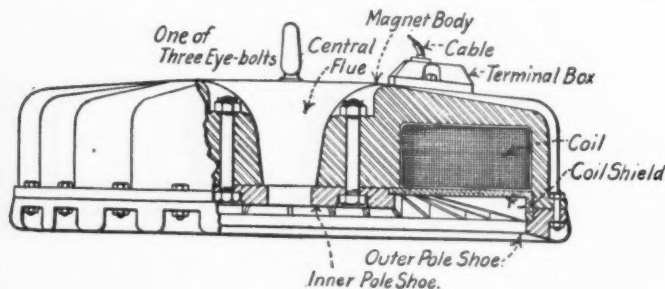
**Car Inspection Shed.**—Adjacent to the substation has been constructed a brick building 136 ft. 6 in. long by 30 ft. 5 in. wide, which will accommodate four cars. The general style of construction is similar to that of the substation. Two tracks run clear through the building, and the openings are enclosed by rolling steel doors. One of the tracks is provided with a pit. A third track, not connected with the outside, is situated in the middle of the building between the two car tracks and a transfer table is located in a cross pit situated about midway in the building, by means of which a truck may be removed from a car and transferred to the center track. A trolley hoist running across the building over all three tracks, and located near one end, is also provided. The pits and building are thoroughly lighted by incandescent lamps and extension plugs have been installed where required. The building is equipped with water, steam and compressed air service.

The facilities offered in this inspection shed are supplemented by the regular division repair shops located near by.

**Operation.**—The car equipment was designed to maintain an average schedule speed of 24 miles per hour with a single car, making one stop per mile over the entire road. Also, with a motor car and one trailer, it is to maintain the same schedule speed with stops about  $2\frac{1}{2}$  miles apart. Shelters have been provided where highways cross the line, there being 22 of these flag stations. In addition there are six regular intermediate way stations where all trains stop or a total of 28 stations where electric cars may be required to stop. The experience so far has shown that electric trains can be depended on to keep their running schedule very closely.

#### LIFTING MAGNETS.

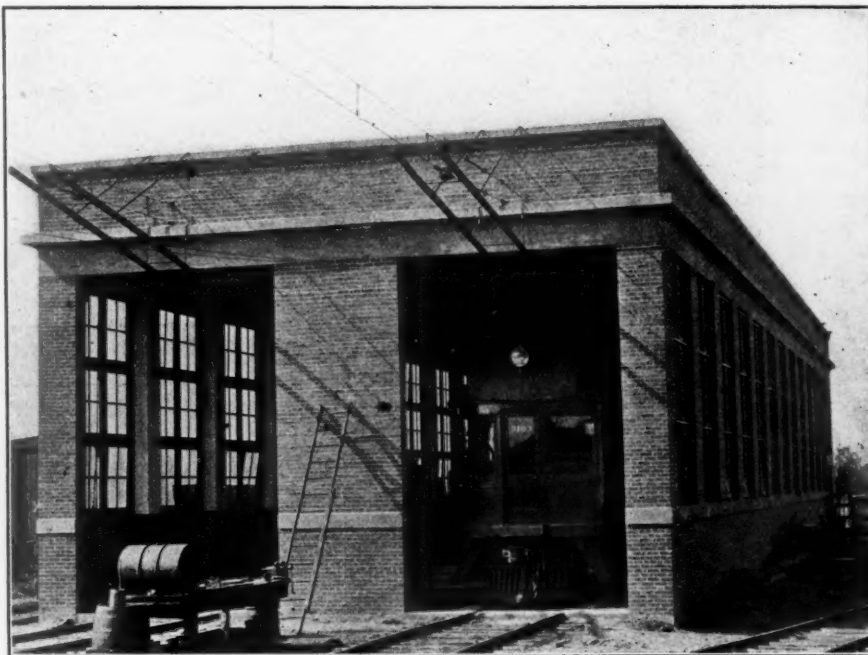
Lifting magnets are being used to splendid advantage at several railroad shop plants in connection with the handling of scrap, boiler plate, castings, etc. No time is lost in adjusting hoisting tackle, and this is specially advantageous in connection with the handling of irregular shaped castings and machined parts. It is only necessary to lower the magnet over the mate-



CUTLER-HAMMER LIFTING MAGNET.

rial and switch on the current, and lift. The magnet will pick up several pieces at the same time, depending upon the nature of the material and the size of the magnet. It will handle metal too hot to touch with the hand.

Under favorable conditions a 50 in. Cutler-Hammer magnet will lift as much as ten tons, while under adverse conditions it might not be able to lift 1,000 lbs. At a test, conducted by the



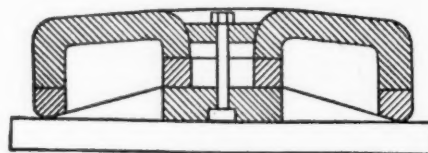
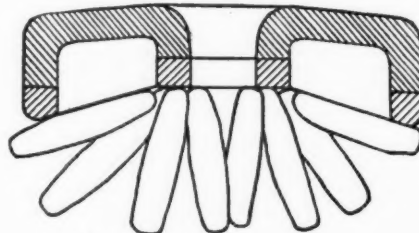
CAR INSPECTION SHED AT AVON—ERIE RAILROAD ELECTRIFICATION.

Youngstown Sheet & Tube Company, Youngstown, Ohio, one of these 50 in. magnets unloaded a steel gondola car containing 109,350 lbs. of full size sand cast pigs, in two hours and five minutes. In doing this the service of only one man was required—the crane operator. The detail data for this test is as follows:

Total weight of pig iron unloaded from steel gondola..	109,350 lbs.
Weight of average lift (including "lean" lifts when cleaning up car) .....	785 lbs.
Trips required to empty gondola.....	139
Current on magnet .....	1 hr. 15 min.
Current off magnet .....	50 min.
Time consumed in unloading gondola.....	2 hrs. 5 min.
Current required to energize magnet.....	30 amperes at 220 volts

On a basis of three cents per kilowatt hour, and this is high, the cost of the electric current required during the test would have been less than twenty-five cents.

The construction of the magnet depends upon the form of the material to be handled. Magnets for handling plates, rails, tubes and similar material are usually made rectangular in shape, although in some cases the circular form answers as well, and are preferably operated in pairs, the two magnets being placed on a balancing bar to which the crane hook is attached. Magnets for handling pig iron, "skull" crackers, or the "skulls" themselves, are usually circular in form and are constructed with a much greater lifting capacity than those designed for handling plates, tubes, etc.



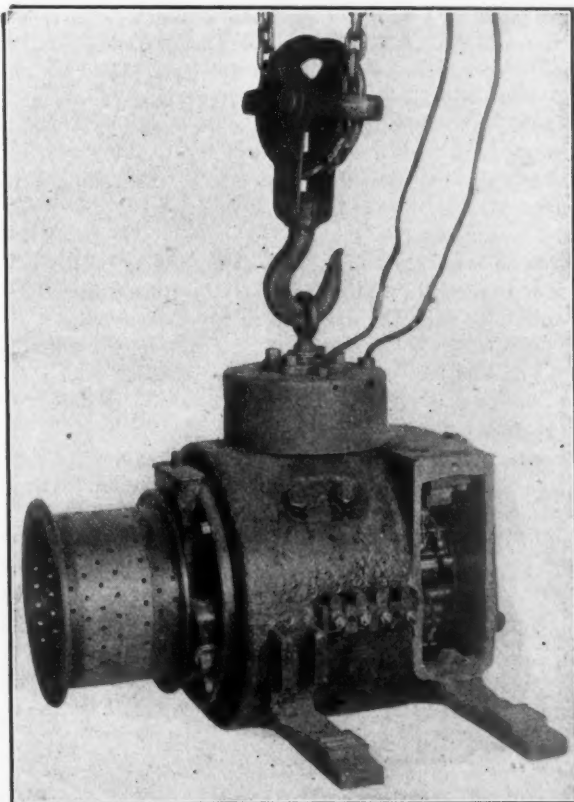
THE CONCAVE FACE MAGNET IS SPECIALLY ADAPTED FOR HANDLING SMALL PIECES AND PIG IRON. WITH THE AUXILIARY POLE PIECE ATTACHED, LONG OBJECTS WITH PLANE SURFACES ARE HANDLED EQUALLY WELL.



LIFTING SMALL PIECES.

A 50 in. Cutler-Hammer magnet weighs about 5,000 lbs. and consists of a hollow steel casting in which a magnetized coil is placed. This coil is carefully built up of alternate layers of copper and asbestos and is insulated from the cast steel frame by thick sheets of mica. No combustible material of any kind is used and the magnet cannot be damaged if it is accidentally left in circuit over night.

In the design of these magnets the magnetic attraction of the inner pole has been purposely made stronger than that of the outer one. In handling pig iron or similar material the bulk of the pieces constituting the lift are therefore drawn toward the

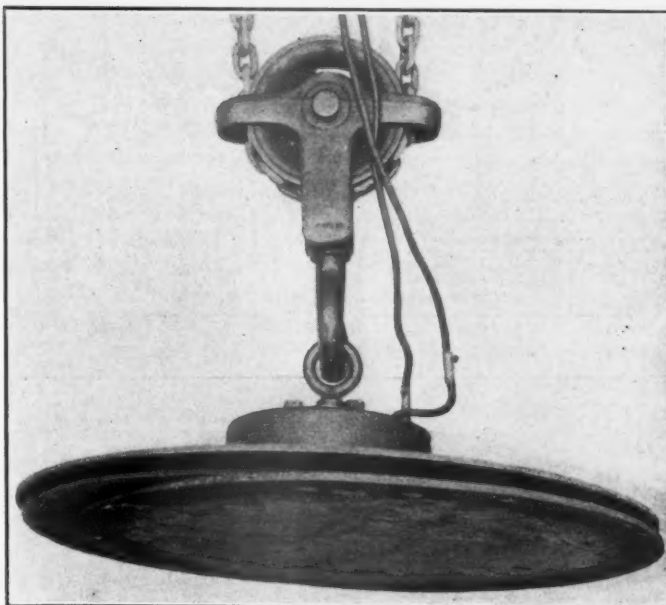


10 INCH MAGNET LIFTING AN 800 LB. BLISS ELECTRIC CAR LIGHTING GENERATOR.

center of the magnet, thus enabling the operator to drop the load within a much smaller area than is possible where the flux is so distributed that the pieces of metal cling to the outer edge of the magnet frame.

The corrugation of the magnet frame provides a greater surface for heat radiation and at the same time forms niches that protect from injury the heads of the through bolts which fasten the removable pole shoe to the magnet frame. The important consideration of heat radiation is further aided by the simple expedient of casting the magnet frame with a central aperture through which air may freely circulate. This prevents the formation of a pocket of dead air in the concave under face of the magnet, and in addition to forming a ventilating flue, reduces the weight of the magnet.

Lifting magnets of large size, designed for use with pig iron, scrap, etc., are made concave on the under side, because this form is best for handling large numbers of irregular shaped pieces of metal at a single lift. When, however, the load consists of ingots or other large objects with plane surfaces, this concavity becomes objectionable, since an air gap intervenes between the inner pole and the object to be lifted. The above mentioned central aperture in the magnets makes it possible to convert them in a few moments from concave faced magnets into magnets adapted for handling large masses of metal with plane sur-



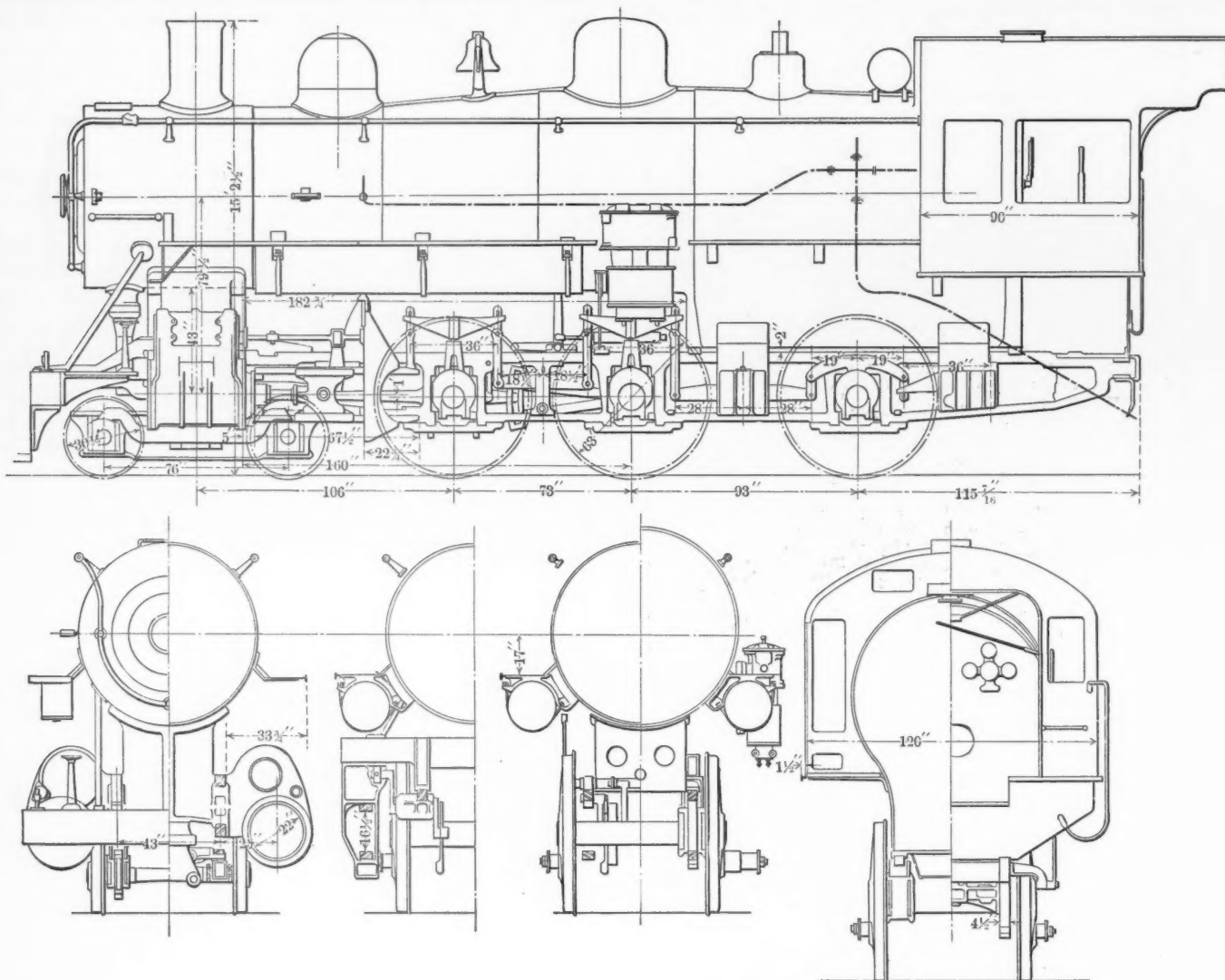
10-INCH MAGNET HANDLING TANK HEADS.

faces. This is accomplished by inserting in the central aperture an auxiliary pole piece so proportioned as to extend the inner pole downward to the level of the outer pole, thus eliminating the air gap and insuring intimate contact of both poles with the object to be lifted.

The pole shoes, which are of course subjected to the greatest wear and tear, are removable, and can readily be replaced when necessary. An improved form of terminal box has been adopted, consisting of a solid casting, doing away with the projecting handle formerly used, which was liable to breakage. The new box is also water tight.

When the circuit is suddenly opened on a magnet coil there is a strong inductive reaction, or "kick," the effect of which is to induce a high voltage at the terminals of the coil. Constant repetitions of this "kick" will sooner or later break down the strongest insulation unless provision is made for guarding against it and dissipating the energy outside of the coil itself. In the Cutler-Hammer system of control the force of the inductive reaction, incident to the opening of the circuit, is minimized by having a discharge resistance automatically shunted across the magnet terminals just prior to the opening of the magnetic circuit, this resistance being disconnected automatically prior to the re-establishment of the magnetic circuit.

These lifting magnets are furnished in any size from 10 to 50 in. by the Cutler-Hammer Clutch Company, Milwaukee, Wis.



ELEVATIONS AND SECTIONS OF TEN-WHEEL OIL BURNING LOCOMOTIVE—SOUTHERN PACIFIC CO.

**TEN-WHEEL PASSENGER LOCOMOTIVE.**

SOUTHERN PACIFIC COMPANY.

The Baldwin Locomotive Works has recently completed an order of twenty ten-wheel locomotives for the Harriman Lines, which have been consigned to the Southern Pacific Company. These locomotives are equipped for oil burning and are the heaviest and most powerful of this type on our records. They weigh over 203,000 lbs. total, of which nearly 160,000 lbs. is on drivers. This gives an average weight per axle of 53,250 lbs., which is unusually large for a ten-wheel locomotive and is above the average modern locomotive of any class. The greatest weight per axle of any locomotive on our records is 58,600 lbs. and the previous maximum for ten-wheelers is 51,333 lbs.

It will be remembered that in 1903 the Harriman Lines adopted a very complete set of standard designs for locomotives,\* which included designs for Atlantic, Pacific, light and heavy consolidation, mogul, and six-wheel switching, but did not include a design of ten-wheeler. The present locomotives were built from designs furnished by the railroad company and can be considered as an extension of the common standards, and, although they differ in many particulars from the previous engines, the details wherever practical have been made interchangeable with them.

These locomotives have a tractive effort of 34,700 lbs. and are intended for service over the heavy grade division between Sacramento, Cal., and Sparks, Nev., a distance of 158 miles. The first 22 miles of this division is of comparatively light grade and one of the locomotives has been designed to maintain an average

speed of  $27\frac{1}{2}$  miles per hour with a 500 ton train. From this point for the next 30 miles the grade is much heavier, having a maximum of 105.6 ft. per mile, and a helper locomotive will be required to maintain a speed of 21.3 miles per hour with the same train. For the next 53 miles, the larger part of which is on a grade of 116 ft. per mile, the average speed with two locomotives will be 16.7 miles per hour.

At this point, 105 miles from Sacramento, the summit is reached and the remainder of the trip is down grade.

The most noticeable change in the common standard design of previous locomotives is found in the boiler, which is of the wagon top type, 72 in. in diameter at the front and contains 355 2 in. tubes. It is of the narrow fire box design, since it is to be used for burning oil and there is no necessity for a large grate area. The mud ring is 5 in. wide on all sides and the water spaces around the fire box have been liberally increased toward the crown sheet.

The general features of design are well illustrated in the drawings and photograph given herewith and the general dimensions, weights and ratios are shown in the following table:

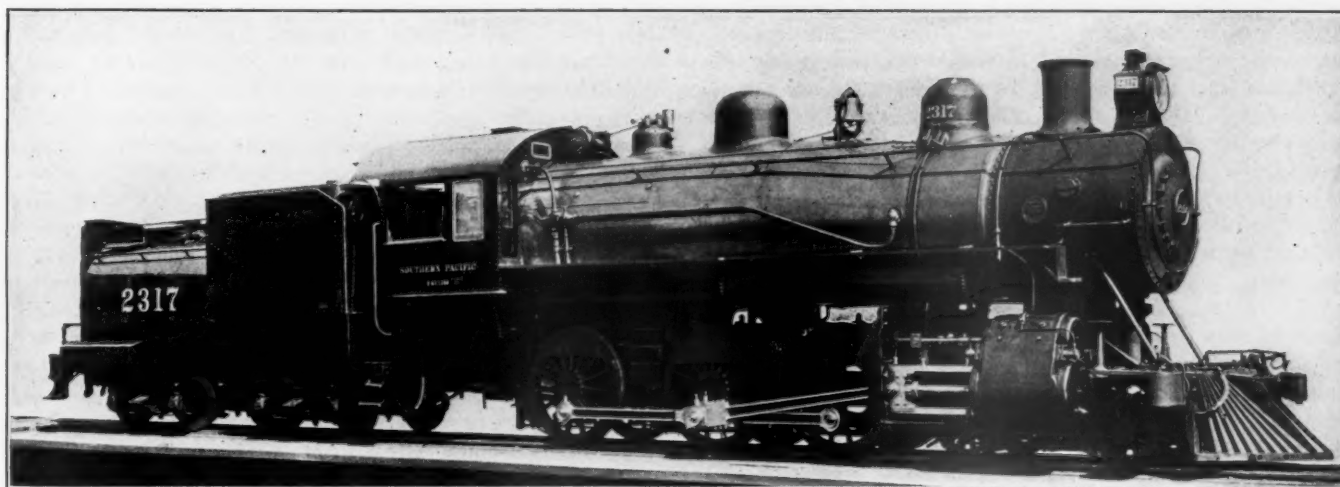
## GENERAL DATA.

Gauge	4 ft. 8 1/2 in.
Service	Passenger
Fuel	Oil
Tractive effort	34,740 lbs.
Weight in working order	203,050 lbs.
Weight on drivers	159,750 lbs.
Weight on leading truck	43,300 lbs.
Weight of engine and tender in working order	344,000 lbs.
Wheel base, driving	13 ft. 10 in.
Wheel base, total	25 ft. 10 in.
Wheel base, engine and tender	58 ft. 10 1/2 in.

## RATIOS.

Weight on drivers ÷ tractive effort	4.58
Total weight ÷ tractive effort	5.85
Tractive effort × diam. drivers ÷ heating surface	730.00
Firebox heating surface ÷ total heating surface, per cent.	6.87

\* See AMERICAN ENGINEER, 1905, pp. 154, 200, 250, 288, 322, 353, 400 and 441.



POWERFUL TEN-WHEEL OIL BURNING LOCOMOTIVE—SOUTHERN PACIFIC COMPANY.

Weight on drivers ÷ total heating surface.....	53.30
Total weight ÷ total heating surface.....	68.00
Volume both cylinders, cu. ft.....	12.30
Total heating surface ÷ vol. cylinders.....	243.00

CYLINDERS.	
Kind.....	Simple
Diameter and stroke.....	22 × 28
Kind of valves.....	Piston
Diameter of valves.....	12 in.

WHEELS.	
Driving, diameter over tires.....	63 in.
Driving, thickness of tires.....	3½ in.
Driving journals, main, diameter and length.....	10 × 12 in.
Driving journals, others, diameter and length.....	9 × 12 in.
Engine truck wheels, diameter.....	30½ in.
Engine truck, journals.....	6 × 10 in.

BOILER.	
Style.....	Wagon Top
Working pressure.....	190 lbs.
Outside diameter of first ring.....	72 in.
Firebox, length and width.....	124 × 37¼ in.
Firebox plates, thickness.....	¾ and ½ in.
Firebox, water space.....	5 in.
Tubes, number and outside diameter.....	355—2 in.
Tubes, length.....	15 ft.
Heating surface, tubes.....	2,788 sq. ft.
Heating surface, firebox.....	206 sq. ft.
Heating surface, total.....	2,994 sq. ft.
Equivalent grate area.....	32.1 sq. ft.

TENDER.	
Wheels, diameter.....	33½ in.
Journals, diameter and length.....	5½ × 10 in.
Water capacity.....	7,000 gals.
Oil capacity.....	2,940 gals.

#### A NOTE ON COMPOUND LOCOMOTIVES.\*

The application of the compound system to the locomotive, although accompanied by an important increase in pressure, and other improvements contributing to ameliorate its working, has not produced generally so great an economy as in the case of stationary, and especially marine, engines, for which the adoption of successive expansions has constituted one of the most considerable transformations that the steam engine has undergone. The simple expansion marine engine practically ceased to exist from the day when compound, and subsequently, triple-expansion engines were introduced on board ships. The simple expansion locomotive, on the contrary, continues to coexist with the compound locomotive.

This state of things has been attributed to two classes of different facts:

(a) The frequency and range of the variations in the work done by the locomotive.

(b) The relatively economical efficiency of non-compound locomotives.

The mode of application to the locomotive, and its complete adaptability to the conditions of the problem, have also been sometimes called in question.

I propose to examine in this note some of the data relating to compound locomotives, and to give alongside of recognized facts some personal opinions. In the first place, it appears to me necessary to recall general elementary and well recognized facts.

\* Abstract of an article by M. Maurice De Moulin, chief engineer of the Western Ry. of France, author of "La Locomotive Actuelle," etc., published in *The Engineer* (London), Aug. 23-30, 1907.

Summing up, the compound system comes to this. Instead of admitting steam during a period "a" into a single cylinder volume V, it is admitted during a period "b" > "a" into, first, a high pressure cylinder of volume "v," and then, secondly, during a period of "c" > "b" into a low pressure cylinder of volume W. By neglecting the influence of clearance and drop in pressure, an engine of this description may be regarded as equivalent to one with a single cylinder of the same volume as the low pressure cylinder, in which the ratio of expansion would be the same. This artifice enables the compound engine to develop the same final degree of expansion, with larger admissions, in the ratio  $W \div v$ . From this property proceed the two principal advantages of the compound method. It allows a large range of expansion to be obtained with ordinary valve gear, without any disorganization of the phases of distribution occurring, such as an excessive increase in lead and of compression, wire-drawing, etc.

It augments the limits of economical expansion by reducing the range of temperature in the cylinders and consequently initial condensation. In addition to these two primordial advantages may be taken into account other causes of economy, or of good working, such as the re-evaporation in the low pressure cylinders of the steam condensed in the high pressure cylinder; the reduction in leaks round the valves and pistons, in consequence of the reduction of the difference in the pressure in each cylinder; the torque is more uniform. In the case of locomotives with four cylinders these advantages are completed by the diminution of fatigue of the parts of the mechanism, thanks to the distribution of the stresses over four cranks, and by the balancing.

The mechanical advantages resulting from the division of the stresses among four cranks are no longer disputed. In fact, both in England and Belgium, four-cylinder non-compound locomotives are in regular service.

The first and last of the causes, quoted above, of the economical working of the compounds, preserve their value under all conditions; the second, relative to the reductions of range in the temperature in each cylinder, becomes less and less important as the velocity of the piston is increased, because of the shorter time allowed for the changes of temperature between the cylinder walls and the steam. It appears certain that for all piston velocities exceeding about 11 ft. per second (28 inch stroke, 72 in. drivers, 30 M. P. H.) it matters but little from a thermodynamic point of view, for range of expansion of six to seven, whether the expansion takes place in one cylinder or in two. On the other hand, when the velocity is very high the first advantage—large expansion—may itself be reduced to a very secondary place, wire-drawing intervening.

So far as the locomotive is concerned, all the working elements—load, inclines, speed—even the force or direction of the wind—undergo to the fullest extent incessant variations. In addition, the locomotive is subjected to a condition which belongs to itself, and the equivalent of which is not to be found

in any other application. It should produce at the moment of starting a maximum tractive force with the minimum of power; and, on the contrary, a maximum amount of horse-power when the tractive force is smaller and the speed high. In other words, contrary to what one observes in fixed and marine engines, the mean effective pressure on the pistons, and consequently the mean value of the torque, are in no respect proportional to the work, and may prove to be, all things equal elsewhere, smaller when the total work is the more considerable.

The proportions of the cylinders can be but a compromise between these contradictory conditions, and the admissions, the range of expansion, the pressure in the valve-chest, undergo variations, very frequent, very important, and irreconcilable with maximum efficiency. We shall be led to observe in the utilization of the steam, variations in relation to those of the work, by which it can be established that for every engine, simple or double expansion, there exists an ascertained initial pressure and a ratio of expansion corresponding to maximum economy. Fatal departures from the economical regime exist, whatever may be the mode of expansion adopted. They may be reduced, but not suppressed, since they are inherent to the method for the production of power.

In any case the efficiency of the steam in the cylinders of the simple expansion locomotive is, all other things equal, proportional to the piston speed, and maximum at high speed, when the effective expansion is a maximum, the injurious influence of the clearance annulled, and the action of the cylinder walls very much reduced. One is led to observe that the wire-drawing, far from being detrimental to the locomotive, is an auxiliary and a corrective of the ordinary valve gear, in the sense that it allows of the realization of a ratio of expansion superior to that which results from single phases of distribution. The only inconvenience which can be attributed to it, the reduction of the mean pressure for a cylinder of given capacity, is without importance, the cylinders of the locomotive, calculated with regard to the effort at starting a train, being too large for normal service.

Considering the normal cycle in the cylinder of a locomotive running at high speed along a fairly level line, one is induced to think that the application of the compound principle would not give any sensible economy, so long as this cycle was maintained. The expansion can reach to seven volumes and clearance is annulled. A compound engine having a ratio of volume of 2.50, and admitting steam to 0.40 per cent. of the high pressure cylinder, would give a nominal expansion of  $2.50 \div 0.40 = 6.25$ . Considering the high velocity of the pistons, it is not necessary to take into account here the special action of the expansion in the two successive cylinders for reducing internal condensation.

One is therefore justified in asserting that for high-speed locomotives running without stopping over nearly level lines, the compound system, such as it is at present, seems to have yielded but a poor economy.

Under contrary conditions, a compound locomotive, working with frequent starting, switching and siding work and having still a ratio of L. P. to H. P. of 2.50 volumes and working 0.50 of admission, the high pressure range of expansion reduced to 0.45 at the most by wire drawing, would realize an expansion of  $2.50 \div 0.45 = 5.5$  volumes instead of 2 to 2.5 volumes, given by the non-compound engine. It will then be more economical, the expansion being greater, and the clearance annulled by compression; besides, the piston speed being less than in the first case considered, the double expansion will involve an expansion of better quality than that of a non-compound engine. It is here that the occasion presents itself for bringing forward an advantage of the compound system which does not appear to have been hitherto sufficiently discussed.

In the non-compound locomotive, the compression is complete only for a determined working, corresponding to a large amount of linking up, and to a piston speed sufficient for the wire-drawing to produce its effect. In the compound engine, the compression is much more complete for all positions of the links, annulling more thoroughly the effect of the clearance.

All existing locomotives are to be classed according to the na-

ture of their service, between the two extreme categories examined above—tractive effort as regular as possible, generally at high speed; tractive effort very irregular and speed variable, and often small. Compounding will have a greater advantage as the conditions approach nearer to the second category, which, I may say, is an opinion opposed to that for a long time previously prevalent. The arguments hitherto put forward allow it to be concluded that compounding presents its greatest advantages for engines when called upon to steam the more frequently with long cut-offs and moderate piston speeds.

On the other hand, it is chiefly in the case of locomotives running at high speed, where the boilers are generally taxed to their maximum of production, that a reduction in the consumption per horse-power is necessary. It may also be accepted that to impart to compounding a superiority under all conditions of working it would be necessary to increase the ratio of the volumes L P to H. P. beyond the proportions frequently adopted, and in all cases not lower than 2.80.

It would be altogether excessive to conclude from what has gone before that the compound type cannot be applied with advantage to high speed locomotives. In fact, these engines work in the ideal condition previously investigated, for a part of the time, and the simple expansion becomes insufficient so soon as these conditions are unfulfilled, and the mean effective cylinder pressure rises above a certain value, especially if the speed falls off in a corresponding proportion. For the starting of trains, the climbing of gradients, and the haulage of heavy trains, the compound system remains at the best for increasing the tractive effort without allowing the consumption of steam to rise in the same proportion. The ratio of minimum expansion should never descend below  $\frac{1}{4}$ . If the compound system yields little or no economy at high speed especially with light trains on the level, or down grade, it will not the less constitute an important equipment, valuable for running up grade, etc. At such times, the economy that it will offer will probably be from 20 to 25 per cent., and if the total economy after a long run does not rise to more than 10 or 12 per cent., one has to distribute over the whole distance an economy which is only obtained over a fraction of the total distance it represents. If it is objected that this total economy is too small to justify the supplementary complication of the compound engine presumably of four cylinders, it must be kept in mind that the compound system has not so much for its object to obtain an economy in fuel as a reserve of power, an increase of tractive effort, without surpassing the capacity of the boiler, over the difficult portions of the line. Even when the total economy would be nothing, if the system permits, with a given boiler, of achieving a greater speed on inclines, or a higher average rate of speed, or the eventual hauling of heavier trains, without a proportional demand on the boiler, its adoption is still rational.

One is thus led to recognize that the compound locomotives, far from lacking that elasticity for the absence of which they have been reproached—present, on the contrary, an elasticity superior to that of simple expansion locomotives to a degree in which perhaps they find their principal advantage.

Many engineers have remained faithful to the simple expansion locomotive, appreciating above all its simplicity and compactness. However, in proportion as the locomotive approaches the limits of possible power, the interest increases more and more in the use of methods intended to augment its power per unit of weight, or grate area and compounding seems one of the most effective methods of obtaining the required result.

When the piston velocity is small, compounding has a thermic effect, the more pronounced as the cut-offs into each of the cylinders are lengthened. On the other side the theoretical efficiency is proportional to the degree of expansion, and consequently inversely proportional to the value of the high and low pressure admission which proceed from them. The most economical rate of working in practice, results then in a compromise between these contradictory conditions.

In virtue of the two principles recalled to mind at the commencement of this note, early cut-offs are contrary to the compound principle, and it appears that the most advantageous work-

ing corresponds to a high pressure admission, bordering upon 50 per cent., which the wire-drawing reduces to 40 per cent., according to the piston speed and the proportions of the ports. If one is obliged further to restrict the high pressure admission in the compound locomotive, it is because the initial pressure is too high, or the volume of the high pressure cylinders too great.

We consider that it would be good practice with compound locomotives to arrange the reversing gear in such a manner that the links could not be fixed in notches included between the dead point and the notch corresponding to 0.45, or 0.50 high pressure admission, which with the inevitable wire-drawing, agrees with the lowest degree of cut-off which appears practically efficient.

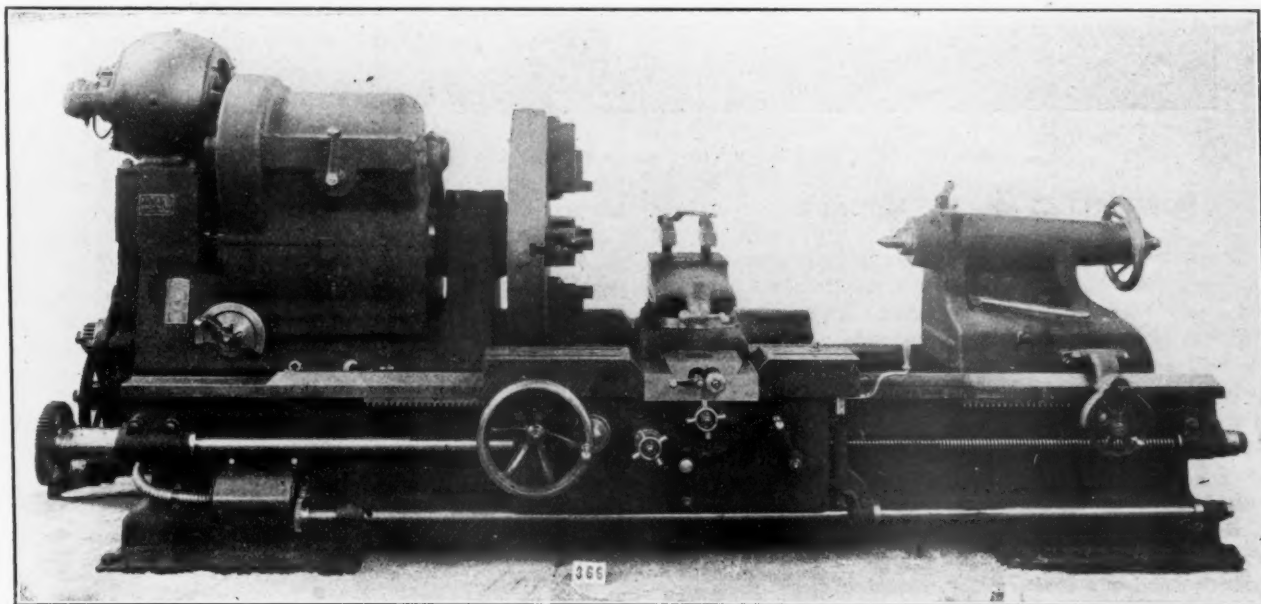
The increase of the minimum high pressure admission, consequently of the low pressure, which are functions, has for consequence the reduction of the initial pressure under certain conditions of working and can even render useful the reduction of the volume of the high pressure cylinders in relation to the proportions adopted at present. There would result from this, on the other hand, the advantage that the relation would find itself increased without augmentation of low pressure volume. The degree of expansion will thus be greater, and the valve gear might become common for the two cylinders of the same group. The only inconvenience would consist in the reduction of the tractive effort at starting, due to the smaller cylinders; but allowing for the steam starting gear with which these engines are furnished, this inconvenience appears to be of secondary importance.

But the advantage of the reduction of the high pressure volume would be especially noted for working with limited power per stroke, with the view of debiting the same volume of steam with longer high pressure cut-off. I think that it will often be found advantageous to reduce the volume of the high pressure cylinders in such a manner that, the low pressure volume not changing from the actually usual proportions, the ratio of volumes would stand between 2.80 and 3.00. Several builders have entered upon this path.

Resuming, this increase of the ratio "w" offers many advantages. It assures a longer expansion at high speed, when the mean pressure should be small; in the case of other working it allows the same degree of expansion to be obtained with longer cut-offs, of which the thermic advantage does not admit of argument; it assures a reduction of the initial stress by securing the least variations in average pressure in each cylinder; and finally it renders possible, practical, and advantageous from every point of view, the employment of only one ordinary valve gear for both high and low pressure, assuring automatically the most advantageous ratio of admission to the two groups, without the intervention of the engine driver, thus preventing all mistakes.

In this order of ideas I would indicate for a compound locomotive having four cylinders, a grate surface of 32.4 to 37.7 sq. ft., and a boiler pressure of 245 lbs., the following proportions:

Diameter of cylinders, H. P. =	14 in.
" " " " L. P. =	23.6 in.
Stroke .....	26 in.
Ratio of volumes .....	2.90



SPRINGFIELD 36-INCH MOTOR DRIVEN ENGINE LATHE.

### 36-INCH MOTOR DRIVEN ENGINE LATHE.

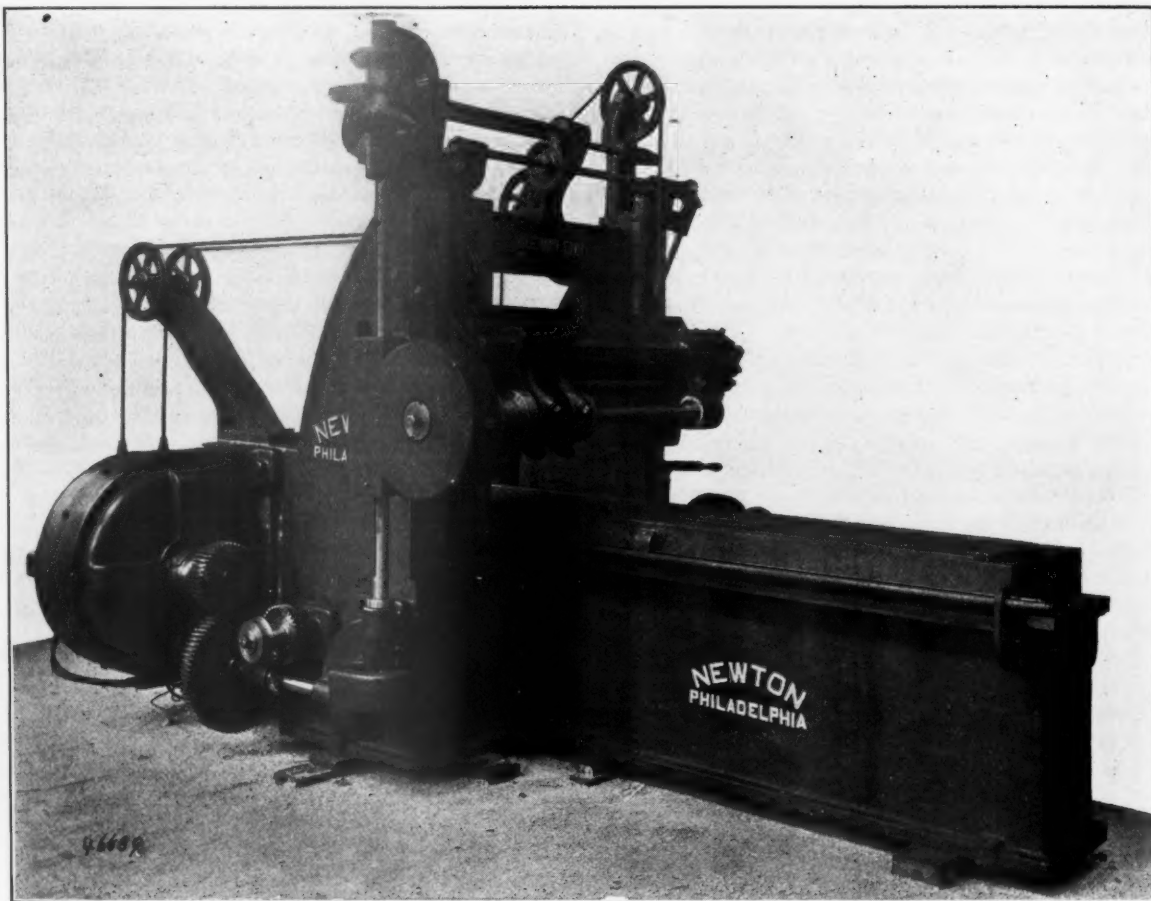
A good example of a compact and efficient motor drive for a large size engine lathe is shown in the accompanying illustration. Those who are familiar with the standard 36-inch engine lathe made by The Springfield Machine Tool Company, Springfield, Ohio, will at once see that the headstock has been entirely re-designed to take the motor drive, the result being a neat, rigid, compact construction. Any kind of variable speed motor may be used; the one shown has a speed range of from 600 to 1,200 r. p. m., obtained by field control. The power required, of course, depends on the class of work which is to be done, but for average requirements the makers recommend a 10 h.p. motor.

Power is transmitted from a rawhide gear, on the motor shaft, to a large gear keyed on an intermediate shaft just above the lathe spindle. On this shaft are three sliding gears, any one of which may be slid into mesh, by means of the handle on the outside of the casing, with one of three gears on a sleeve on the spindle. This with the back gears makes six different spindle speeds available, which in conjunc-

tion with those furnished by the motor provide a wide range with ample power. The motor controller is attached to the side of the bed, near the head end, and is operated by a handle, at the right side of the carriage, through suitable gearing and a splined shaft.

A pair of cone gears, suitably supported at the rear end of the headstock and manipulated by the handle shown on the front side of the headstock, furnishes three sets of ratios for feeds and screw cutting. They may be thrown in or out while the lathe is running. Power feed is furnished for the top slide of the compound rest, as well as for the cross and longitudinal motion of the carriage. All feeds are engaged by means of frictions and reverse motion is controlled at the apron.

The tail stock is clamped to the bed by four large bolts and may be moved back and forth by a handle which, through suitable gears, operates a pinion which engages with the rack, as shown. A taper attachment may be supplied, if desired, which is of an improved type, arranged so that it may be connected or disconnected instantly by loosening one bolt and tightening another, or vice-versa.



NEWTON HORIZONTAL MILLING MACHINE.

### HORIZONTAL MILLING MACHINE.

The American Locomotive Company has recently received several small plain horizontal milling machines from the Newton Machine Tool Works, Philadelphia, similar to the one shown in the illustration. The table is 23 in. wide and of sufficient length to mill a piece 14 ft. long. The uprights will admit work 30 in. wide and the center of the spindle can be raised 30 in. above the table. They are driven by 2 to 1 variable speed, 25 h.p., General Electric motors. The spindle is 5 in. in diameter, has a side adjustment of 6 in. and is driven by a phosphor bronze worm wheel and hardened steel worm with a roller thrust bearing, which runs in oil.

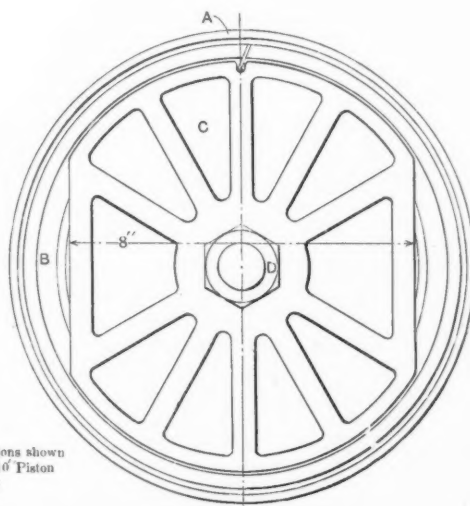
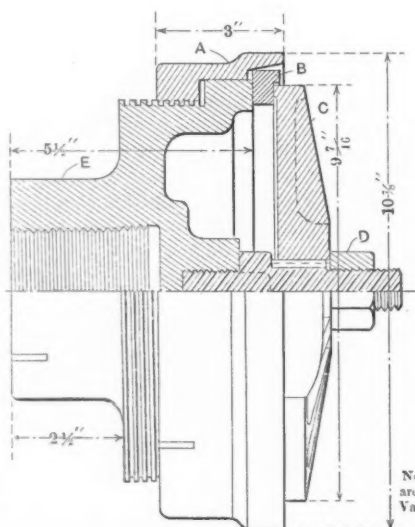
The cross rail is of the inclined face design, is counterweighted and has both hand and rapid power motion in both directions. The lifting screws are so designed that they are in tension when drawing the cross rail down, thus eliminating any tendency to buckle. For convenience in working around bosses and oil cups forged on connecting rods, the center of the spindle is carried  $2\frac{1}{2}$  in. below the bottom of the rail. The cutter arbor is driven by a face or "butterfly" key and the out-board arbor support is fitted with a taper bushing to compensate for wear.

The table is operated by a spiral pinion and rack, has nine changes of geared feed and is so designed that it is held rigidly in any position to prevent it from working back when sinking into the cutter. The table has a rapid power motion in both directions and the lever which controls this motion, and also the rapid

power motion of the cross rail, is conveniently placed on the operating side of the machine. The machine weighs about 28,000 lbs. and is practically self-contained, as the motor is bolted rigidly to the uprights. It is specially adapted for the milling of small side rods and similar work of this class, of which there is a large variety in railroad repair shops.

### CHUCK FOR VALVE AND PISTON PACKING RINGS.

A chuck for holding snap packing rings, after they have been rough turned and the slot has been milled out, is shown in the accompanying illustration. The advantage of this device lies in the fact that it compresses the ring equally on all sides in clos-



Note: Dimensions shown are for use on 16" Piston Valve Packing

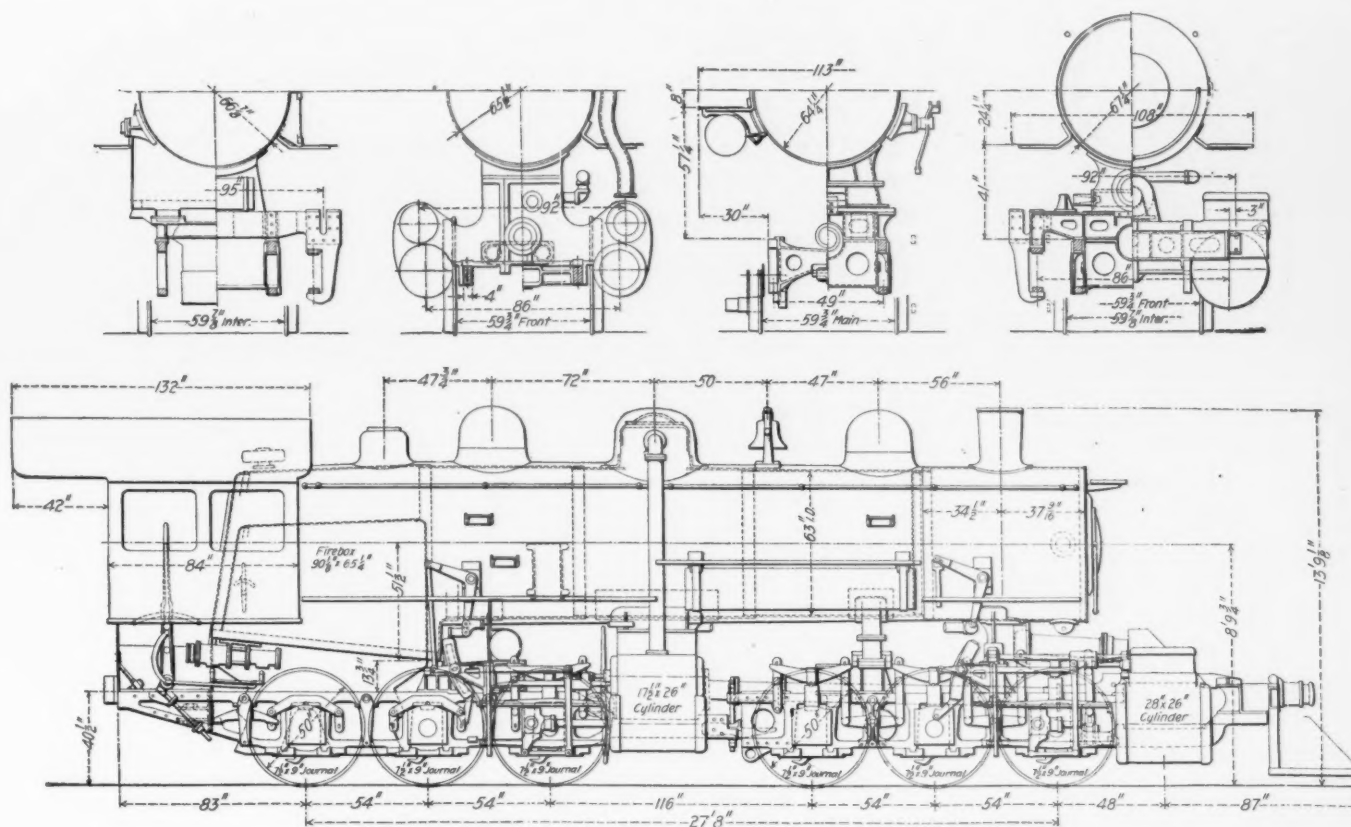
VALVE AND PISTON PACKING RING CHUCK.

ing it up for the finishing cut, so that it will exert an equal pressure on all sides of the valve bushing or cylinder when in place. It also will be of equal section at all points and hence be less liable to breakage.

Using the letters as shown in the illustration, the method of using this chuck is as follows: The packing ring, B, having been previously turned to  $\frac{1}{8}$  in. larger than the diameter of the valve chamber or cylinder and a  $\frac{3}{16}$  in. section having been cut out at an angle of 45 degs. is placed in the chuck, which is in place on the spindle of the lathe, and plate, C, is held lightly against

it by nut D. Ring A is then screwed up with a spanner wrench and its inner beveled edge compresses the ring equally on all sides until the slot is closed. The nut D is tightened up and plate C will hold the ring in position. Ring A is then moved back out of the way and the packing is trued up to the correct diameter.

This chuck was designed and has been patented by Mr. John Rusche, general foreman of the Grand Crossing shops of the Chicago, Burlington & Quincy Railway, where it has been in very successful use for several years.



MALLET COMPOUND LOCOMOTIVE FOR ROAD SERVICE, CENTRAL RAILWAY OF BRAZIL.

### MALLET COMPOUND FREIGHT LOCOMOTIVE.

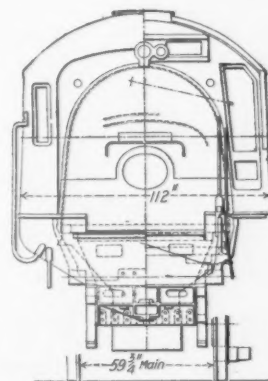
CENTRAL RAILWAY OF BRAZIL.

The American Locomotive Company has recently delivered a Mallet compound locomotive to the Central Railway of Brazil, which presents an interesting example for study in connection with a consideration of this type of locomotive for regular road service. This is the lightest Mallet compound ever built by this company and weighs but 206,000 lbs. total, all of which is on the six pairs of drivers.

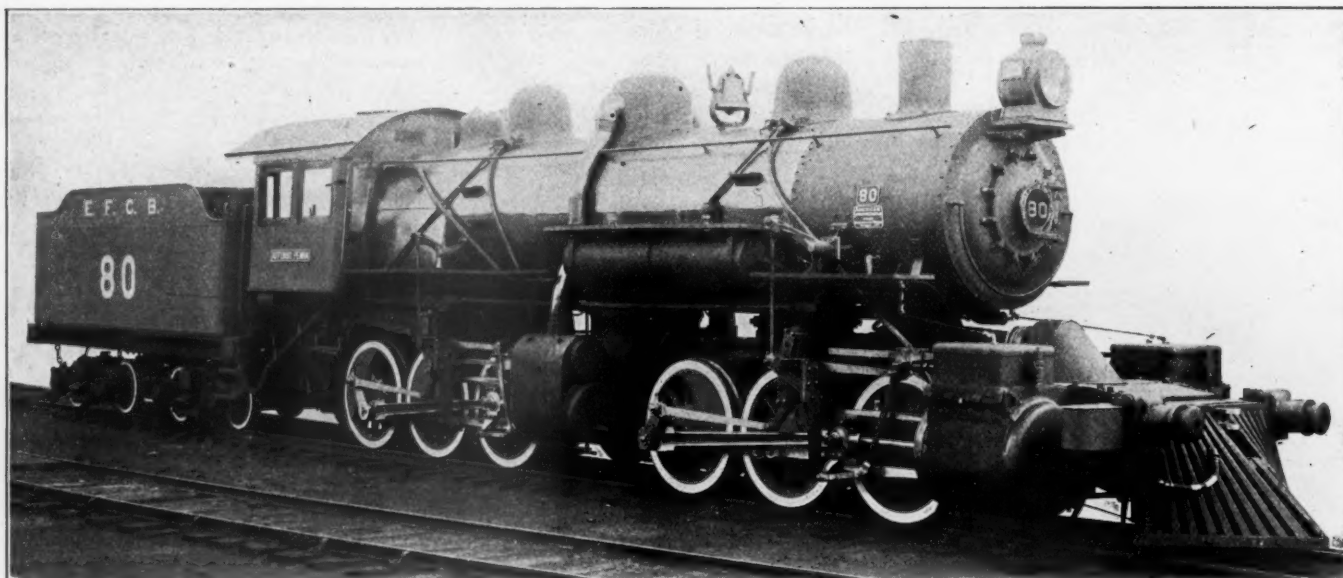
Comparing this engine with one of the consolidation type, many features of advantage in favor of the Mallet, especially on roads with heavy grades, sharp curves and light road beds, are evident. The design under consideration presents a tractive effort of 42,420 lbs., with an average weight per axle of 34,333 lbs. and a rigid wheel base of 9 ft. Assuming that the axle weight was limited to this figure, the heaviest consolidation which it would be possible to use would weigh but 152,400 lbs. and would deliver a tractive effort of but 28,200 with the same factor of adhesion, while at the same time it would have a longer rigid wheel base. If it was desired to obtain the tractive effort given by this engine in the shape of a consolidation, assuming the same factor of adhesion, such a locomotive would weigh 229,000 lbs. total and would give a weight per axle of 51,500 lbs. A consolidation of the same total weight would give a weight per axle of 46,350 lbs. and deliver a tractive effort of but 38,200 lbs. These figures clearly

indicate that under conditions limiting the weight per axle, and especially if the rigid wheel base is also restricted, the Mallet compound offers practically the only opportunity to obtain great power from one machine.

Another feature of advantage, in cases where the facilities for repair are not of the best, is shown in this design by the lightness



of the different parts, as for instance, the main rods, which weigh but 417 lbs., in comparison with 825 lbs. on a heavy consolidation. The same ratio of weights also holds for a number of other parts. The disadvantage of the multiplicity of moving parts and general duplication of the running gear is undoubtedly more



SMALL MALLET COMPOUND LOCOMOTIVE FOR ROAD SERVICE—CENTRAL RAILWAY OF BRAZIL.

than offset by the advantages mentioned above, and it would seem that this type has fully as great a future in connection with light power for road service as it is generally admitted to have for the heavier classes of work.

In general, the design of this locomotive is a small edition of both the Baltimore & Ohio and Erie locomotives built by the same company. It, however, does not contain some of the special features found on the heavier engine, such as a floating balance device, spring centering arrangements, etc.

The general weight, dimensions and ratios are as follows:

GENERAL DATA.	
Gauge .....	4 ft. 8½ in.
Service .....	Freight
Fuel .....	Cardiff Coal
Tractive effort .....	42,420 lbs.
Weight in working order .....	206,000 lbs.
Weight on drivers .....	206,000 lbs.
Weight of engine and tender in working order .....	304,300 lbs.
Wheel base, rigid .....	9 ft.
Wheel base, total .....	27 ft. 8 in.
Wheel base, engine and tender .....	55 ft. 2¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort .....	4.88
Total weight ÷ tractive effort .....	4.88
Tractive effort × diam. drivers ÷ heating surface .....	905.00
Total heating surface ÷ grate area .....	56.30
Firebox heating surface ÷ total heating surface, per cent. ....	5.25
Weight on drivers ÷ total heating surface .....	89.00
Total weight ÷ total heating surface .....	89.00
Volume equivalent simple cylinders, cu. ft. ....	11.20
Total heating surface ÷ vol. cylinders .....	207.00
Grate area ÷ vol. cylinders .....	3.66
CYLINDERS.	
Kind .....	Mellin Comp.
Diameter and stroke .....	17½ and 28 × 26 in.
VALVES.	
Kind .....	H. P. Piston, L. P. Slide
Greatest travel .....	H. P. 5 in., L. P. 5½ in.
Outside lap .....	¾ in.
Inside clearance .....	3/16 in.
Lead in full gear .....	3/16 in.
WHEELS.	
Driving, diameter over tires .....	50 in.
Driving, thickness of tires .....	3 in.
Driving journals, diameter and length .....	7½ × 9 in.
BOILER.	
Style .....	Straight
Working pressure .....	200 lbs.
Outside diameter of first ring .....	64¼ in.
Firebox, length and width .....	90¾ × 65¾ in.
Firebox plates, thickness .....	¾ and ½ in.
Firebox, water space .....	F. 5, S. and B. 4 in.
Tubes, number and outside diameter .....	234—2 in.
Tubes, length .....	18 ft.
Heating surface, tubes .....	2195.2 sq. ft.
Heating surface, firebox .....	121.5 sq. ft.
Heating surface, total .....	2316.7 sq. ft.
Grate area .....	41 sq. ft.
Smokestack, diameter .....	16 and 19 in.
Smokestack, height above rail .....	13 ft. 9½ in.
TENDER.	
Tank .....	Water Bottom
Frame .....	10 in. Channels
Wheels, kind .....	Rolled Steel
Wheels, diameter .....	30 in.
Journals, diameter and length .....	5 × 9 in.
Water capacity .....	4,500 gals.
Coal capacity .....	8½ tons

STOCKHOLDERS OF THE PENNSYLVANIA RAILROAD.—Some very interesting figures have been obtained by the compilation of the

holdings of the Pennsylvania Railroad Company's stock on October 1, 1907. The capital stock of the company on that date was \$312,061,900 divided into 6,241,238 shares. These shares are held by 49,572 persons, making the average holding of each at 126 shares. Of the total number of shareholders 46.92 per cent. were women. 19.27 per cent. of the entire capital stock of the company is held abroad. The average holdings of the 8,526 stockholders in foreign countries being 141 shares each. At the present rate of increase it is stated to be likely that when the books were closed on November 5, for the payment of the semi-annual dividend, the stockholders of the company would number more than 50,000.

LONG NON-STOP RUN.—The Great Western Railway of England on September 16 ran a special train from London to Fishguard, a distance of over 263 miles, without a stop. The train returned on the second day following, also without a stop. The outbound trip was made in a total of 298 minutes, or at an average speed of 53 miles per hour; the return trip was made at an average speed of 53½ miles per hour. The train consisted of four 70 ft. passenger cars and a 73 ft. dining car, and was drawn by a 4-4-0 type engine.

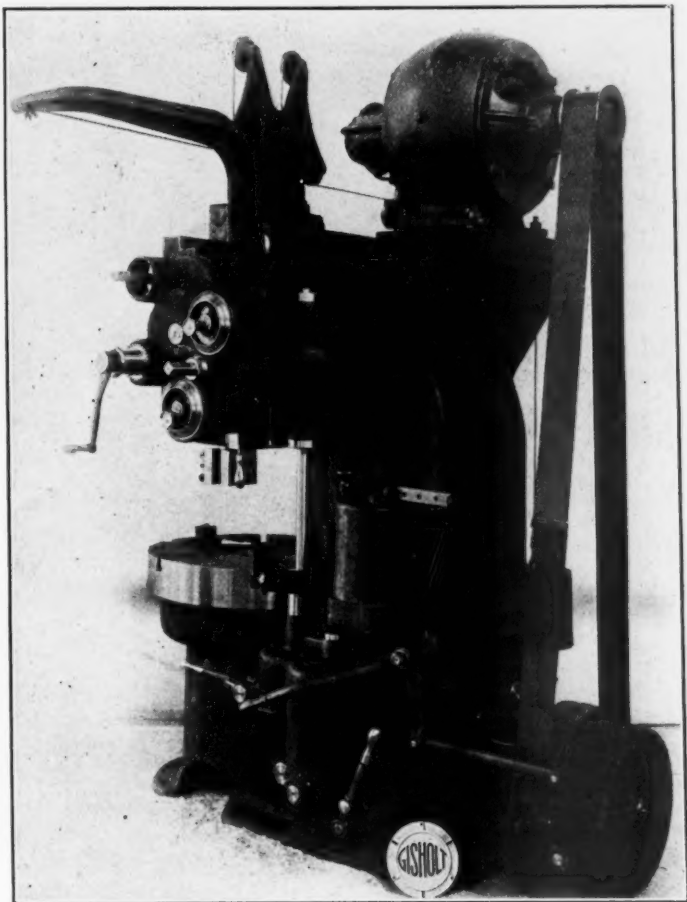
AUXILIARY EXHAUST TO EQUALIZE DRAFT.—A conclusive test of the auxiliary exhaust is advisable because, with the modern large power with its high steam pressure and great volume of exhaust, light and economical firing is practically impossible without some method of equalizing the draft through the firebox and softening the exhaust when working at full stroke and under heavy throttle.—*Report of Committee, Traveling Engineers' Association.*

NO SAVING IN FUEL BY ELECTRIFICATION.—Viewed in the light of greatest benefits to be secured, the coming of the electric locomotive is not due to petty economies effected in coal consumption and cost of locomotive repairs; indeed, with coal as a common source of power, little gain in efficiency is secured through burning the same grade of fuel under stationary boilers over the excellent results obtained with the highly perfected modern compound locomotive.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

NEW TESTING LABORATORY.—What is said to be one of the most complete railroad testing laboratories in this country has been completed at the new Omaha shops of the Union Pacific Railroad Company. This laboratory occupies part of the new shop office building and includes complete equipment for both physical and chemical tests of all kinds, as well as bacteriological investigations, photographic work, electrical experiments, metallurgy, etc.

## MOTOR DRIVEN BORING AND TURNING MILL.

An interesting application of a variable speed motor drive to a Gisholt boring and turning mill is illustrated herewith. The 5 h.p. motor has a 4 to 1 speed range (400 to 1,600 r. p. m.). The three-step cone pulley used on the belt driven machine is replaced by a single friction pulley which is controlled by the long lever shown in the illustration. The table is thus under absolute control of the operator and may be started, stopped, or moved any part of a revolution at will. The motor is carried



GISHOLT MOTOR DRIVEN BORING AND TURNING MILL.

on a substantial bracket and the controller is attached to the frame of the machine.

The machine may be furnished with either a plain table or chuck and has an extreme swing of  $36\frac{1}{2}$  in. It is provided with eight gear driven feeds and with a friction device to guard against stripping the gears through careless handling. All feed screws are fitted with micrometer index dials reading to .001 in.; the tool in the turret may be moved .001 in. or more in any direction without the use of a scale. A feed tripping device makes it possible to automatically throw off the feed at any predetermined point; it will also positively trip any feed at either end of the feed traverse whether the dials are set or not.

**STANDARDIZING GRADES OF COAL.**—It is recommended that an effort be made to bring about the standardizing of grades of coal furnished for locomotives. That the desirability of better grades of coal, both in the line of economy and convenience, is unquestionable, but if managements cannot be brought to realize the economy of good coal, or, if it is impossible to obtain it at all times, efforts should be made to insure the furnishing of one particular grade at all times, in place of from half a dozen to 20 different varieties. No mechanic on earth could turn out satisfactory work if you changed the style and pattern of his tools daily, and it is just as impossible for the fireman to do himself justice or work for the best interests of his employers if a continual change is being made in the kind of fuel he must use.—*Report of Committee, Traveling Engineers' Association.*

## A RECORD IRON PRODUCTION.

The Refined Iron and Steel Company of Pittsburg, in the month of August, made what is said to be a record production of muck bar, considering the number of furnaces in operation. The output for that month was 1,198 tons from seven double puddling furnaces. The average number of furnaces in use during the month was six per day and the greatest production of any one day of twenty-four hours was  $83\frac{1}{2}$  tons.

The furnaces in use in this mill were especially designed according to the ideas of Mr. William Stubblebine, general manager of the company, who expected the maximum capacity of the seven furnaces would be 70 tons a day, and a record of  $83\frac{1}{2}$  tons is thus particularly gratifying.

It might be added that there is a prospect of this record being exceeded because of the fact that four single heats were lost because of the shortage of raw material and a few turns on account of excessive heat.

This company is giving the matter of the quality of its iron even closer consideration than quantity records. That it is being equally successful in this respect is shown by the figures in the following tables, which give the results of careful tests made by disinterested parties on three different grades of iron. The different grades of iron were obtained by different methods of piling and heat treatment.

Not being satisfied to rest on its laurels, however, the company is continually increasing the capacity of its plant, and has recently finished some mills which will enable it to produce bar iron from puddled muck bar which will be put on the market in competition with common bar iron.

## STAY BOLT IRON.

Specimen.	Diameter, in.	Length, in.	Tensile Strength, lbs. per sq. in.	Elastic Limit, lbs. per sq. in.	Per Cent. Elongation.	Per Cent. Contraction of Area.
1 in. rd.	1.005	8	49,130	31,610	30.00	48.7
$\frac{7}{8}$ in. rd.	.887	8	49,540	34,860	30.25	49.6
1 in. rd.	1.000	8	49,560	33,020	29.75	47.4
$\frac{7}{8}$ in. rd.	.890	8	50,160	34,370	27.75	47.5
1 in. rd.	1.005	8	49,790	33,720	29.25	46.5
$\frac{7}{8}$ in. rd.	.890	8	50,910	36,380	29.75	40.1

## DOUBLE REFINED IRON.

Specimen.	Diameter, in.	Length, in.	Tensile Strength, lbs. per sq. in.	Elastic Limit, lbs. per sq. in.	Per Cent. Elongation.	Per Cent. Contraction of Area.
$\frac{7}{8}$ in. rd.	.878	8	51,930	37,850	25.5	37.2
1 in. rd.	1.003	8	50,570	33,910	28.25	35.1
$1\frac{1}{4}$ in. rd.	1.255	8	50,410	32,150	26.25	40.7

## SPECIAL ENGINE BOLT IRON.

Specimen.	Diameter, in.	Length, in.	Tensile Strength, lbs. per sq. in.	Elastic Limit, lbs. per sq. in.	Per Cent. Elongation.	Per Cent. Contraction of Area.
1 in. rd.	1.005	8	55,500	38,040	26.25	43.6
1 in. rd.	1.007	8	55,270	38,050	27.50	46.0
1 in. rd.	1.010	8	54,470	36,170	27.50	46.3
1 in. rd.	1.010	8	54,890	37,620	28.75	46.3

**CAR FERRY ON LAKE ONTARIO.**—The Buffalo, Rochester & Pittsburg Railway and the Grand Trunk Railway have established a car ferry across Lake Ontario between Rochester, N. Y., and Coburg, Ont. The first boat for this service has recently been put into operation and is the largest ever operated on Lake Ontario, being 317 ft. in length, and 57 ft. 7 in. beam. It has a capacity for 26 freight cars and is sufficiently powerful to operate throughout the winter season. In addition to carrying freight cars it is also designed for the accommodation of passengers. Two round trips will be made in each 24 hours.

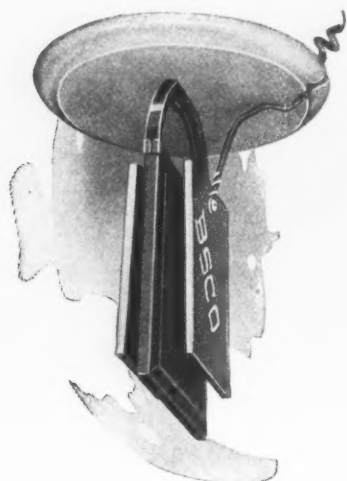
**ENGINEERING LIBRARY OPEN EVENINGS.**—The reference libraries in the United Engineering Societies Building, New York, are opened on all week days, except holidays, until nine o'clock in the evening. These libraries are available to the members of the Associated Societies and to the public generally subject to the proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies. This building is located at 29 W. 39th street, New York City.

**ELECTRIFICATION OF MOUNTAIN GRADE DIVISIONS.**—There are other items of saving and other reasons for electrification which may be more or less controlling in individual cases, but it seems possible to make the broad statement that the mountain-grade division offers a particularly attractive field for the electric locomotive, and its introduction should be the means of affecting such economies in both freight and passenger transportation as to pay a satisfactory return upon the investment required.—*Mr. A. H. Armstrong before the Amer. Inst. Elect. Engineers.*

## A NEW PRIMARY BATTERY.

A new type of battery, which is of unusually substantial construction, and conveniently arranged for renewal, has recently been developed, primarily for automatic signal purposes. It is, however, also adaptable to other fields where a first-class primary battery is desired.

This battery is of the caustic soda or copper oxide type and consists of a porcelain jar with a porcelain cover to which is fastened a supporting frame or hanger holding the zinc and copper oxide plates. The supporting hanger is secured to the cover by a single large wing nut on the top and the removal of this permits all of the elements of the battery to be released and a new set inserted in their place. The hanger of channel section is formed in a U shape and carries the copper oxide plate between its extending arms. This plate is securely fastened to the hanger and the two zinc plates are hung one on either side from a porcelain insulator, which passes through and is supported by a cross bar at the top of the copper plate. There is but one piece of wire in the battery, that being securely fastened to the zinc plate



and passing through a slot in the porcelain cover. The other connection is made to the extension of the bolt holding the supporting hanger.

The advantages derived from this method of arranging and fastening the elements are, that it is possible to place the plates much closer to each other than usual without danger of short circuiting, thereby greatly reducing the internal resistance and thus increasing the capacity of the cells. There is also no danger of the plates coming into contact since in renewing the battery the hanger with both sets of plates is thrown away and a complete new set, already rigidly fastened together, is inserted. The zincs in this type of battery are completely immersed and hence the danger of their being eaten off at the surface of the solution is eliminated.

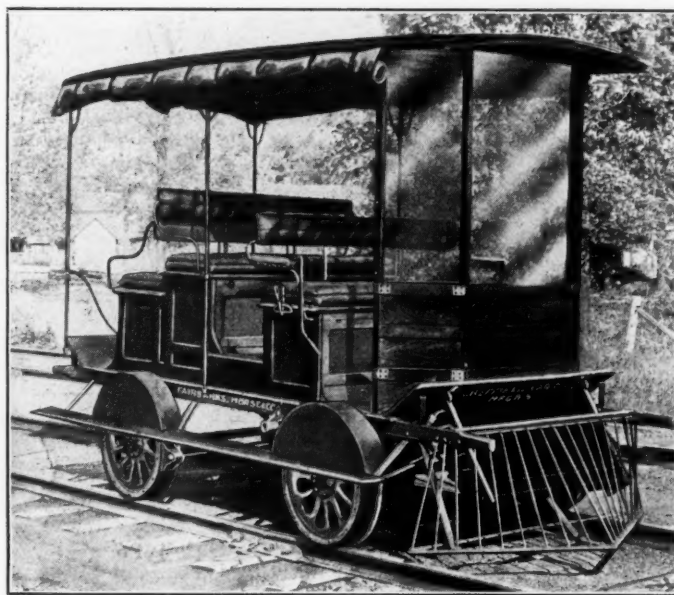
The model of this battery designed for signal work has a capacity of 350 ampere hours and the mean working voltage of .7. The voltage for open circuit is .95. This battery, which is called the "BSCO," is manufactured by the Battery Supplies Company of Newark, N. J.

**THE MAGNITUDE OF THE BALDWIN LOCOMOTIVE WORKS.**—The report of the committee on science and arts, given in the *Journal* of the Franklin Institute for October, contains some interesting figures on the size of the Baldwin Locomotive Works, some of which are shown in the following table:

Number of men employed.....	19,000
Number of buildings comprised in the works.....	47
Horse power employed, steam engines.....	12,138
Horse power employed, oil engines.....	4,850
Acreage of floor space comprised in the buildings.....	6.32
Aggregate h. p. of electric motors.....	14,200
Number of electric motors.....	1,115
Consumption of coal, tons per week.....	3,000
Consumption of iron, tons per week.....	5,000
Consumption of other material, tons per week.....	1,460

## GASOLINE MOTOR CAR FOR RAILWAYS.

It is now generally admitted that the most satisfactory method of making railway inspection of any nature is by means of a gasoline motor car, and Fairbanks, Morse & Company recognizing this fact are making a specialty of this class of equipment. A number of different designs for special purposes and of varying carrying capacities and weights are being manufactured. The car illustrated has a seating capacity for nine people and is equipped with a top, glass front, and side curtains, making it



GASOLINE MOTOR CAR FOR INSPECTION SERVICE.

available for use in any kind of weather. These cars are capable of very high speeds, at the same time having a wide range in speed and can be operated as slowly as desired for the most careful inspection of track.

The results obtained from a trip by the chief engineer of the Michigan Central Railway indicate the efficiency and speed of these cars. This trip, which covered a total of 2,327 miles, showed an average of 19 miles per gallon of gasoline; 97 miles per battery cell and 517 miles per gallon of lubricating oil. At one part of the trip 39.6 miles were made in 45 minutes, giving a rate of nearly 53 miles per hour; at another point 66.4 miles were covered at a rate of 40 miles per hour.

**LARGEST STACK IN THE WORLD.**—The Boston & Montana Consolidated Copper & Silver Mining Co. is building a stack at Great Falls, Montana, which will be 506 ft. high and have an internal diameter of 50 ft. The first 23 ft. is octagonal in shape, built of concrete, the remainder being constructed of hollow fire brick. It is said that the pressure on the foundation will be 5 tons per square foot.

**PNEUMATIC FIRE DOOR CLOSER.**—A wider investigation of the pneumatic firebox door closer and the mechanical stoker should be made, because the steady increase in the size of power will in all probability necessitate the adoption of some such devices in the interests of economy and of the firemen.—*Report of Committee, Traveling Engineers' Association.*

**STEAM TURBINES IN AMERICA.**—Although it has been less than a decade since the first steam turbine was operated in this country it is stated that there are to-day about 700 in use, aggregating about 1½ million horse power.

Of the seventeen million dollars paid out by the relief department of the Pennsylvania Railroad since 1886 ten million was paid on account of disablements and seven million in death benefits.

**ELECTRIC SWITCHING LOCOMOTIVE.**

Large manufacturing plants having a number of buildings covering considerable area have found it necessary to build and equip switching railroads within their own confines. Where electric power is convenient and cheap, or for reasons of cleanliness, noise, etc., it has often been found advisable to electrically equip these roads using small electric locomotives for handling trains of either narrow or full gauge cars.

The Cervceria Cuauhtence Brewery of Monterey, Mexico, is a plant of this kind, and the 25-ton electric switching locomotive shown in the accompanying illustration has been purchased



ELECTRIC SWITCHING LOCOMOTIVE.

of the Jeffrey Mfg. Co., of Columbus, O., and put into operation at that point. The switching locomotives built by this company are of the same general type and take the same electrical equipment as its well-known electric mine locomotives. The only changes made in the illustrated case are in the side and end frames and the addition of the platform and a suitable cab. This locomotive has two motors of the water-proof type, with drum wound armature and laminated pole pieces.

Locomotives for this service are being built in sizes from 10 to 30 tons, with two motors, and in larger sizes with 3 and 4 motors. These are arranged with rigid frames or with double trucks having a flexible wheel base, as conditions may require.

**TESTING SIDE THRUSTS ON RAILS.**—The Pennsylvania Railroad has equipped a section of track, about 166 ft. in length, with rails and cast steel ties of special design, which permit the rail to have a slight movement over the tie, it being maintained in line by an instrument which will register the force with which the flanges of the wheels strike against the rail. In connection with these tests both steam and electric locomotives, as well as various types of cars, are operated at various speeds over this section of the track and it is expected that the final results will give accurate information concerning the side thrusts on the rails, and incidentally on the flanges of the wheels. These tests have brought out the erroneous report in many newspapers that the Pennsylvania Railroad was making a comparative speed test of steam and electric locomotives. While both types may be operated at their maximum speeds at some time during the tests no attempt is being made to compare the speed qualities of the two types.

**NEW YORK RAILROAD CLUB.**—At the last annual meeting of this club the following officers were elected for the ensuing year: President, H. H. Vreeland; vice-president, J. F. Deems; 2nd vice-president, W. G. Besler; 3rd vice-president, H. S. Hayward; treasurer, R. M. Dixon, and a new member of the executive committee, George W. West.

**PERSONALS**

Mr. James Carr has been appointed master mechanic of the Midland Valley R. R., with office at Muskogee, Ind. T., succeeding Mr. C. H. Welch.

Mr. M. M. Dooley has been appointed master mechanic of the Alabama Great Southern R. R. at Birmingham, Ala., succeeding Mr. J. W. Evans, promoted.

Mr. H. R. Knight has been appointed master mechanic of the Western Maryland Ry., with headquarters at Elkins, W. Va., vice Mr. R. C. Evans, promoted.

Mr. J. N. Wilber, master mechanic of the Chicago, Burlington & Quincy Ry. shops at Hannibal, Mo., has resigned, having completed 50 years' service with this company.

Mr. W. Gell has been appointed master mechanic of the Ottawa division of the Grand Trunk Ry., with headquarters at Ottawa, Ont., in place of Mr. Donnelley.

Mr. J. R. Donnelley has been appointed master mechanic of the Northern division of the Grand Trunk Ry., with headquarters at Allandale, Ont., vice Mr. Markey.

Mr. J. F. Graham, superintendent of motive power of the Oregon Railroad & Navigation Co., has had his authority extended to include the Corvallis & Eastern R. R.

Mr. E. A. Wescott has been appointed superintendent of the car department of the Erie Railroad, with headquarters at Meadville. The position of Asst. Mech. Supt. has been abolished.

Mr. D. W. Cunningham has resigned as master mechanic of the Chicago, Rock Island & Pacific Ry. at Valley Junction, Ia., to enter the service of the Missouri Pacific Ry.

Mr. E. H. Smith, heretofore traveling engineer for the Boston & Albany R. R., has been appointed division master mechanic at Allston, Mass., succeeding Mr. A. J. Fries.

Mr. J. W. Evans, master mechanic of the Alabama Great Southern R. R. at Birmingham, Ala., has been appointed division superintendent at the same point.

Mr. Axel Johnson has been appointed general foreman of the car department of the Lake Shore & Michigan Southern Ry. at Collinwood, O., succeeding Mr. J. W. Senger.

Mr. W. H. Hufmann, master mechanic of the Chicago & Northwestern Ry. at Baraboo, Wis., has retired, having completed 50 years in the service of that company.

Mr. J. Markey has been appointed master mechanic of the Middle division of the Grand Trunk Ry., with headquarters at Toronto, Ont., in place of Mr. W. Kennedy, resigned.

Mr. W. I. Rowland, general foreman of the Baltimore & Ohio R. R. at Grafton, W. Va., has been promoted to division master mechanic at the same place to succeed Mr. O. J. Kelly, resigned.

Mr. W. B. McDermott, master mechanic of the St. Louis, Iron Mountain & Southern Ry. at Texarkana, has been appointed master mechanic of the St. Louis Southwestern Ry. at the same point.

Mr. C. F. Ludington has been appointed chief fuel supervisor of the Atchison, Topeka & Santa Fe Ry., with headquarters at Topeka, Kan.

Mr. J. J. Reid has been appointed master mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., in place of Mr. R. G. Long, resigned.

Mr. E. I. Dodds has been appointed assistant superintendent of the car department of the Erie Railroad, with headquarters at Meadville, and the position of Asst. to Mech. Supt. has been abolished.

Mr. C. C. Barclay has resigned as district superintendent of the Pullman Company at St. Paul, Minn., to become connected with the mechanical department of the Northern Pacific Ry. at Livingston, Mont.

Mr. T. Tracy has been appointed assistant superintendent of the car department of the Erie Railroad, with headquarters at Meadville, and the position of Asst. M. C. B. has been abolished.

Mr. Albert Bowman, master car builder of the Cairo division of the Cleveland, Cincinnati, Chicago & St. Louis R. R., has resigned to accept a similar position with the Toledo & Northwestern R. R.

Mr. Frank Cain, master mechanic of the St. Louis Southwestern Ry. at Texarkana, Tex., has resigned to become assistant general master mechanic of the Houston & Texas Central Ry. at Houston, Texas.

Mr. J. W. Senger has been appointed supervisor of materials of the Lake Shore & Michigan Southern, Lake Erie & Western and Lake Erie, Alliance & Wheeling Railways, with headquarters at Collinwood, Ohio.

Mr. William H. Lungren, foreman of car shops of the Philadelphia, Baltimore & Washington R. R. at Wilmington, Del., having been for 54 years in the service of the Pennsylvania Railroad, has been retired under the pension rules.

Mr. A. L. Moler has been appointed master mechanic at Beaumont, Texas, of the Orange & Northwestern R. R., the Colorado Southern, New Orleans & Pacific and the Beaumont, Sour Lake & Western Railways. He takes the place of Mr. J. A. Baker, resigned.

Mr. A. J. Fries, master mechanic of the Boston division of the Boston & Albany R. R., with office at Allston, Mass., has been appointed master mechanic of the Albany division, with office at Springfield, Mass., succeeding Mr. P. T. Lonergan, resigned.

Mr. William Kennedy, master mechanic of the Grand Trunk Ry. at Toronto, Ont., has been appointed superintendent of motive power of the Central Vermont R. R., with office at St. Albans, Vt. Mr. Kennedy succeeds Mr. Archibald Buchanan, Jr., resigned.

Mr. R. L. Doolittle, asst. master mechanic of the Central of Georgia R. R. at Macon, Ga., has been appointed master mechanic of the Atlanta, Birmingham & Atlantic R. R. at Fitzgerald, Ga. The position of superintendent of motive power of this road has been abolished.

## BOOKS

Strength of Structural Timber. By W. Kendrick Hatt. Pamphlet; 6 x 9; 39 pages. Published by the Forestry Service, U. S. Department of Agriculture, Washington, D. C. Free on application.

This is the second progress report on this subject and gives the results of tests made by the Forestry Service to show the strength and stiffness of different timbers. There is much of interest and value to the user of structural timber in these results.

Pumps; Notes on the Construction and Working. By Edward C. R. Marks; 5 x 7½; cloth; 259 pages; illustrated. Published by D. Van Nostrand Co., 23 Murray St., New York. Price \$1.50.

This is the second and enlarged edition of this work, which covers the latest developments in all classes of pumps, particularly those of the centrifugal type for high lift service, which have made the greatest advance during the last few years. As is indicated by the size of the book, the subject is very completely covered in a clear cut, simple style and includes very little of a theoretical or mathematical nature. In addition to the pumps proper there is much valuable information given in connection with the arrangement of pipes and connections, sizes of pipes, etc., as well as a brief history of the development from the primitive designs. The sectional and line illustrations make the subject matter exceptionally clear.

Modern Steam Traps, Their Construction and Working. By Gordon Stewart; 5 x 7½; cloth; 104 pages; illustrated. Published by D. Van Nostrand Co., 23 Murray St., New York. Price \$1.25.

This book does not profess to deal exhaustively with the subject, but is, so far as we know, the first work published dealing exclusively with steam traps. It covers the points which are most vital to the proper and efficient working of such apparatus and illustrates and describes the construction of practically every design of steam trap used in America or England. The book is divided into nine chapters, each of which considers a different general type of steam trap. The illustrations are in the form of sectional views or line drawings clearly showing the interior construction and the operation of the different traps, while the accompanying type matter simply and clearly explains its operation and points out the conditions for which different types are specially adapted. A very complete index is included, adding materially to the value of the book.

How to Use Water Power. By Herbert Chatley; 5 x 7½; cloth; 92 pages. Published by D. Van Nostrand Co., 23 Murray St., New York. Price \$1.00.

This book is not advanced as an exhaustive treatise on the subject, but it is intended for the use of young and inexperienced engineers and gives a clear account of the methods and principles of hydraulic engineering, as at present practiced, in a form that can be easily grasped by the workman or student with a limited knowledge of mechanics and mathematics. The keynote of the work is simplicity and utility. The first chapter deals with the sources of power and explains the methods of figuring the amount of energy to be obtained under different conditions. The second chapter is on transmission and losses of power and gives data for computing the loss in any case. Following this are chapters on the hydraulic press, its application; water wheels; turbines; pumps; hydraulic engines; tidal power; water supply; sewerage disposal and dams, all of which are well illustrated and clearly explained.

Mechanical Drawing. By Ervin Kenison. 6¾ x 9¾; cloth; 138 pages; illustrated. Published by the American School of Correspondence, Chicago, Ill. Price \$1.00.

This work is designed not so much as a manual for the teacher of drawing as a means of self-help and self-instruction for the student. It forms one of a series of hand-books on allied subjects which lay special stress on the practical side of each subject. The book is divided into four parts, the first one of which illustrates and describes the construction and application, as well as the method of using, the different drawing instruments and appliances; gives examples of lettering, dimensioning, etc., and is followed by problems with explanations of their solution, which will give the student a proficiency in the handling of all the different instruments. The second chapter considers the geometrical definitions, giving examples and problems on each part, and is followed by a chapter on geometrical problems covering all of the simpler and generally used problems of this

kind. The last chapter considers projections, including shade lines, intersections, etc. This book will be found to be of special value as a supplement to a course in mechanical drawing.

**Principles of Reinforced Concrete Construction.** By F. E. Turneaure and E. R. Maurer. 6 x 9; cloth; 316 pages; illustrated. Published by John Wiley & Sons, 43 E. 19th St., New York. Price \$3.00.

This work covers, in a systematic manner, those principles of mechanics underlying the design of reinforced concrete and presents the results of all available tests that may aid in establishing co-efficients and working stresses and gives such illustrations from actual designs as may be needed to make clear the principles involved. It is essentially divided into two parts, the first six chapters treating of the theory of the subject and results of experiments and the remaining four of the use of reinforced concrete in various forms of structures. In the introductory it is stated that the invention of reinforced concrete should be credited to Joseph Monier, who, in 1861, constructed tubs and tanks of concrete surrounding a framework or skeleton of wire. Following this is an historical sketch of the development, uses and advantages of this material for different purposes. The work is profusely illustrated and condenses into either tabular or curved form all of the vital information needed by a designer of reinforced concrete structures.

**Machine Shop Work.** By Fred W. Turner. Cloth; 6¾ x 9¾; 190 pages; illustrated. Published by the American School of Correspondence, Chicago, Ill. Price \$1.50.

This is another work of the same series as the work on mechanical drawing mentioned above, and is stated to be a manual of approved methods in modern shop practice, including the construction and use of the latest types of improved tools and machines and other details of modern shop equipment and operation. The author is an instructor of machine shop work in the Mechanics Arts High School, Boston, Mass., and has arranged the book in four parts. The first section deals with tools operated by hand, such as hammers, chisels, measuring instruments, files, drills, etc., and gives illustrations of construction of each tool, together with the proper method of using it. The second part deals with the lathe and devotes 52 pages to instructions and explanations of the proper procedure for doing different classes of lathe work, being profusely illustrated with line drawings and half-tones and including instructions in proper design and grinding of tools. The third part is on drill presses and planing machines, which are treated in a similar manner, as is also the fourth part on milling and grinding machines. This book will prove to be of great assistance to an apprentice in a shop where a regular shop instructor is not provided, as well as an adjunct to such instructor under other conditions.

**A Treatise on Hydraulics.** By Prof. Wm. C. Unwin. 6 x 9; cloth; 327 pages; illustrated. Published by Adam and Charles Black, London. (Macmillan Co., 64 Fifth Ave., New York, Agents.) Price \$4.25.

The reputation of the author's previous works on this and allied subjects is a sufficient indication of the value of this treatise to any one familiar with them. A casual examination indicates that the same exact and accurate treatment found in the previous books has been followed in this case. As is pointed out in the preface, there now exists an enormous mass of experimental data relating to hydraulic problems which has been accumulating during a period extending over two centuries, and which is of very varying trustworthiness and importance. For a decision on questions which arise in many branches of professional work it is necessary that the engineer should realize the limitation of the formulas given and be acquainted with the degree of confidence which can be placed in them. While this book does not attempt to completely cover all of this field, it gives in every case full reference to the primary sources of information and confines itself to the proper application of the results. The problems concerning the flow of incompressible fluids are accompanied by similar problems concerned with compressible fluids such as air, steam, gases, etc. The arrangement

of the work is in the form of a text book, carefully explaining by means of diagrams each of the principles and giving a number of practical examples or problems in connection with each chapter. The chapter on statics and dynamics of compressible fluids gives the principles and their application for the flow of air through orifices, in pipes, through valves, etc. The application for steam and other gases is also included.

**The Use of the National Forests.** Bound in cloth. 5 x 7 in.; 42 pages. Illustrated. Published by the Forest Service, U. S. Department of Agriculture, Washington, D. C. Free upon request.

There are now about 145 million acres of national forests in the U. S. and about 5 million acres more in Alaska and Porto Rico. Many people do not know what national forests are, and others who have heard about them have little idea of their true purpose and use. The national forests very closely concern all of the people of the country, especially those in the West, and affect directly or indirectly many great business interests. The object of this publication is to explain just what they mean, what they are for and how to use them. It takes up the subject of the causes leading to the establishment of forest reserves, the first of which was authorized in 1891, and proceeds to explain the early mistakes made in establishing boundaries, which lead to considerable criticism of the movement; it shows how these mistakes have been corrected; explains the value of the national forests to the home seeker, who can settle in a national forest if he so desires; to the prospector and miner, who are absolutely free to travel about and explore such forests and work claims in them the same as he would on a public domain; to the users of timber, who can obtain as much or as little timber as may be desired from the national government; to the user of the range, who is allowed to graze his cattle in the national forests and to the public in general, which is greatly benefited in many indirect ways. A number of most interesting illustrations are included, showing how valuable timber lands have been absolutely destroyed for any purpose, by private lumber corporations and also how by wise timbering methods forests can be carefully cut and will continue to be productive. Instructions are also included in this book for the procedure to be followed for obtaining rights for settling, mining, timber, etc., and tables showing the exact location, together with their area, of all of the national forests now controlled by the government are appended.

## CATALOGS

IN WRITING FOR THESE PLEASE MENTION  
THIS JOURNAL.

**MILLING CUTTERS.**—Catalogs "A" and "B" from the Harrison & Knight Mig. Company, Newark, N. J., describe a large variety of high speed milling cutters made by them. These include both the solid and inserted tooth types.

**ONE-LOCK ADJUSTABLE REAMER.**—An illustrated description, as well as a price list of these, is presented in a pamphlet received from the Wm. J. Smith Company, New Haven, Conn. They are said to be easy of adjustment and a comparatively low maintenance cost is claimed.

**INDUCTION MOTORS.**—The Barrett Electric Mfg. Co., Cincinnati, O., is issuing bulletin No. 106, describing its type of induction motors, which are made in all sizes from ¼ to 50 H. P. and for two or three phase circuits. These machines are claimed to be practically fool proof, and almost indestructible and are designed to stand rough usage without depreciation.

**THE ELECTRIC LOCOMOTIVE IN HEAVY PASSENGER AND FREIGHT WORK.**—A large number of present and proposed representative types of electric locomotives built by the General Electric Co. are illustrated and described in Bulletin No. 4537 now being issued. Sketches are given of electric locomotives weighing from 17 to 150 tons for all classes of service. Electric and mechanical data as well as the characteristic curves of each are given, also some interesting features of their construction.

**COAL AND ASH HANDLING MACHINERY.**—The Jeffrey Mfg. Co., Columbus, O., is issuing a 56-page catalog illustrating and describing many recent installations of machinery for handling coal and ashes in power plants, which cover almost any conceivable arrangement for receiving, discharging and storing. This company manufactures conveyors and elevators of several different types, each one being specially adapted to certain conditions, all of which are illustrated in this catalog.

**ALUNDUM, ITS INVENTION AND USE.**—The Norton Company, Worcester, Mass., is issuing a leaflet describing the manufacture of alundum and its remarkable value as an abrasive. Illustrations are included showing different steps in the manufacture of this material.

**PRISMATIC WATER GAUGE.**—The Ashcroft Mfg. Co., 85 Liberty street, New York, is issuing a pamphlet descriptive of its design of prismatic water gauge. The construction of the gauge is clearly explained and the advantages of this type over the ordinary water glass are shown. The gauge is so constructed as to fit in the place of the usual water glass, the regular boiler fittings being retained.

**PORTABLE STORAGE BATTERIES.**—The Westinghouse Machine Company is issuing a very attractive catalog on the subject of portable storage batteries, which are illustrated in a great variety of sizes. The illustration of each type is accompanied by a table showing all of the important features, dimensions and capacities, as well as the price. The batteries of this type are used for car lighting, electric locomotives, electric vehicles, automobiles, etc. No batteries of the stationary type are shown in this catalog.

**AUTOMATIC GEAR CUTTING MACHINE.**—Gould & Eberhardt, Newark, N. J., are issuing a 60-page catalog illustrating and describing their different types of patented gear cutting machinery, which are the product of 60 years' experience as specialists in this line. The catalog shows machines for cutting spur gears, as well as for cutting bevel, skew and face gears. A section is given up to the description of attachments for these machines and a number of machines for special work are also illustrated.

**STORAGE BATTERIES.**—The Gould Storage Battery Co., 341 Fifth avenue, New York, is issuing a pamphlet which includes a thorough description of its special method of manufacturing plates for storage batteries, showing views of separate plates and complete installations. Bulletins Nos. 8 and 9 are also being sent out by the same company, the former describing the storage battery plant of the Dayton & Western Interurban Railway and the latter the plant of the Rutland Railway, Light and Power Company, which shows the application of storage batteries to alternating current systems.

**STEELS.**—Samuel Bros., 132 Front street, New York, American agents for Cammell Laird & Co., of Sheffield, England, is issuing catalog B, covering the products of that company. This includes steels of practically all kinds for high speed tools, files, chisels, saws, springs, sheet steel, forgings, gears, axles, and in fact any appliances usually made of this material. The catalog is illustrated with views of the manufacture and colored plates of labels for different grades and also includes a colored chart giving the temperature corresponding to different shades as well as some very good advice in connection with the handling and heat treatment of tool steel.

**SHAPERS.**—Gould & Eberhardt, Newark, N. J., are issuing a very attractive catalog on the subject of high duty shapers and attachments. A large variety of these machines are very completely illustrated and the construction is described in detail. In the section on attachments for shapers are shown special designs of vises and mandrels, index centers, circular tables, automatic feeds, electric motor drive attachments and many special devices for doing work not ordinarily considered within the field of the shaper.

**ELECTRICAL APPARATUS.**—The General Electric Company is issuing two new bulletins, one of which deals with direct current motor starting rheostats, shown in two types, both of which are suitable for use with shunt, compound or series wound motors. These rheostats are for one minute duty with a no-voltage release and one of the types also has an overload coil. They are made in many different capacities. The other bulletin is on the subject of catenary line material. It contains 32 pages given up to a very complete description of the devices manufactured by this company for this class of equipment. It is profusely illustrated with views of catenary construction, in detail, as well as general.

**ROLLER BEARINGS FOR RAILWAY CARS.**—The Standard Roller Bearing Company, 5003 Lancaster avenue, Philadelphia, is issuing a pamphlet giving the results of tests made with a street car on the street railways of Syracuse, N. Y., fitted with the Merrick roller bearing, which consists of a series of rollers fitted around the journal and within a specially constructed journal box. This car was tested in comparison with a similar car fitted with the ordinary brasses and showed a saving of 55 per cent. in the amount of current used to operate over the same line, which in this case means a saving of \$292.00 per car per year. The test is fully described and the curves of the power used on the different cars are included.

**LIFTING MAGNETS.**—A 32-page pamphlet just issued by the Cutler-Hammer Clutch Co., of Milwaukee. It contains a number of full page illustrations showing lifting magnets handling pig iron, steel stampings, castings, scrap and other material, together with diagrams, data on current consumption, information on lifting capacity of magnets, etc. A new cable take-up device is described and reference is made to the Cutler-Hammer system of control by which the strong inductive reaction, or "kick," which occurs when the circuit is suddenly opened on a magnet coil, is automatically shunted to a discharge resistance, thus protecting the magnet insulation by dissipating the energy of the induced voltage outside of the coil itself.

**FRICTION CLUTCHES.**—Catalog C from the Carlyle Johnson Machine Company, 356 Asylum street, Hartford, Conn., presents an illustrated description of the Johnson friction clutch and its various applications.

**SAND BLAST APPARATUS.**—Under the title of "Railroad Sandcraft," Mr. C. Drucklich, 132 Reade street, New York City, has issued an interesting and valuable little pamphlet which discusses the uses and advantages of the sand blast in railroad shops and for cleaning bridges and steel work. A description of the Injector sand blast, which is manufactured by the above concern also appears, as well as directions as to its use. Where compressed air and dry sand are not available it is necessary to provide a supplementary outfit, which is briefly described.

**THE ELECTRIFICATION OF THE WEST SHORE RAILROAD.**—The General Electric Company is issuing a handsomely bound pamphlet of 24 pages in which the electrified section of the West Shore Railroad, between Utica and Syracuse, N. Y., is very completely illustrated and described. This is a direct current, 600 volt, third rail system, obtaining current by a 60,000 volt three phase transmission line from the hydro-electric power house of the Hudson River Power Company. Views of the electric trains, transmission lines, substations, plans of buildings, wiring diagrams and details of the track construction are shown and each feature is clearly described. Not the least interesting feature is a comparison of train sheets showing the service before and after electrification.

## NOTES

**BALDWIN LOCOMOTIVE WORKS.**—This company received a diploma of a gold medal for a most admirable, efficient and artistic installation of exhibit at the Jamestown Exposition.

**KENNICOTT WATER SOFTENER COMPANY.**—This company is furnishing a great many steel water storage tanks to different railroads. They are said to be much more economical than the wooden ones, as they last twice as long and cost less than one-half as much to maintain.

**PRESSED STEEL CAR COMPANY.**—The Pressed Steel Car Company and the Western Steel Car and Foundry Co., have opened offices in the National Bank of Commerce Building, 5th and Olive streets, St. Louis, Mo., with Mr. W. P. Coleman, assisted by Mr. C. D. Terrell, in charge.

**AMERICAN LOCOMOTIVE COMPANY.**—The directors of this company, in a meeting held on November 6, re-elected the retiring officers to serve for the ensuing year. Mr. S. P. Callaway was elected to succeed Mr. Leigh Best as secretary. Mr. Best continues to hold the office of vice-president.

**IRON AND STEEL BROKERS.**—H. B. DeHart and W. H. Stafford have established an office at 29 Broadway, New York, for the transaction of a general commission and brokerage business in iron and steel products, including structural work, shapes, bars, light rails, malleable and steel castings, cast iron, etc. Both members of the firm are engineers and have had long experience in this field.

**AMERICAN BLOWER COMPANY.**—In the exhibit of this company at the conventions of the American Street and Interurban Railway Associations at Atlantic City, was included the suspended ball feature which attracted so much attention at the mechanical conventions in June. The explanation of the phenomenon of the ball remaining suspended in the air without apparent support can be secured by addressing the company at Detroit, Mich.

**MEETING OF THE A. S. M. E.**—The 54th annual meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies Building, New York, December 3 to 6. The subjects to be taken up at this time include foundry practice; specific heat of superheated steam; low grade fuels in gas producers and other live topics such as industrial education, power transmission by friction, cylinder port velocities, etc., will be discussed.

**WESTINGHOUSE RECEIVERSHIP.**—The receivers of the Westinghouse Machine Company announce that there should be no occasion for apprehension because of the company's application for receivership. This action was taken as being the most sensible measure for conserving the interests of the customers, creditors, and stockholders of a solvent institution, which is doing a large and profitable business. There will be no departure from the general policy as heretofore followed in the conduct of the business and no pause in the operations of the company, the personnel of which remains the same as heretofore.

**CARSE BROTHERS CO.**—The resignation of Mr. Davis B. Carse from the chairmanship of the advisory committee of the United States Steel Corporation will permit him to again actively take up the business of the above company, which deals largely in machinery and supplies for railway work. The company has been recently reorganized and its headquarters have been removed from Chicago to 12 Broadway, New York. In reorganizing the company it has incorporated with it a department for electrical specialties, which will place it in a position to handle the electrical equipment of electrified steam railways.

